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REMOTE ONTARIO
BIOMASS ASSESSMENT STUDY

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REMOTE ONTARIO

BIOMASS ASSESSMENT STUDY

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and
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Prepared by:

Bird and Hale Ltd.
Jellicoe Resource Associates Ltd.
The D.P.A. Group Inc.

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ABSTRACT

BIRD AND HALE LTD.
in cooperation with Jellicoe Resource Assoc. Ltd.
and the D.P.A. Group Inc.

This report contains the findings of a study to determine the technical viability and cost of supplying wood and peat feedstock to biomass fuelled generating systems in four remote communities in northern Ontario.

The communities identified as having the highest potentials for economically viable operation of a biomass fuelled generating system, listed in descending order, are, Fort Hope, Armstrong, Weagamow (Round Lake) and Gull Bay.

Five tube boiler/steam engines with capacities of 500,300 and 200 kw respectively were identified as the optimum biomass fuelled generating systems for Fort Hope, Weagamow and Gull Bay. Two types of biomass systems were identified as appropriate to supply the 1,000 kw capacity required in Armstrong; these are a water tube boiler/steam turbine or gasifier/dual fuel engine. Use of the gasifier/dual fuel engine is contingent upon successful demonstration of the technology and economic analysis.

The supply of wood biomass appears to be technically viable at all of the study communities using available technology.

Armstrong is the only study community that has a sufficient source of peat. However, supply of this peat does not appear to be feasible using available dry mining technology.

The estimated 1984 cost of wood biomass, per green tonne, delivered to generating systems in the study communities is, Fort Hope $26.40, Armstrong $23.23, Weagamow $33.66, and Gull Bay $34.50.

Fort Hope has the highest potential of the study communities for economically viable operation of a biomass fuelled generating system.

EXECUTIVE SUMMARY

INTRODUCTION

There are 44* communities in northern Ontario that are considered to be remote regarding their sources of energy supply. Remote communities are defined as areas of population containing more than ten permanent households which are not connected to a main electrical grid. Fossil fuels are the primary source of energy supply for these communities. Diesel generators are presently used to produce electrical power for the majority of communities and others do not presently have electrical service. Fuel oil or wood are used for space heating in the homes and commercial and institutional buildings. Propane, naptha and kerosene are also used for cooking, heating and lighting.

The costs for purchasing and transporting fossil fuels and maintaining the generating systems in the communities which have electrical service are rapidly increasing, as is the demand for electrical power in the communities which do not presently have electrical service. Consequently this study was commissioned by the Ontario Ministry of Energy with the support of Energy Mines and Resources Canada.

This report contains a summary of the findings of a study to determine the potential and to estimate the cost of supplying wood and peat (muskeg) feedstock to biomass fuelled generating systems in selected remote northern Ontario communities.

The use of peat (muskeg) as biomass feedstock was investigated for one community and the use of wood biomass was investigated for four communities.

In this report biomass is defined as forest fibre (wood, bark, limbs, etc.) or peat (muskeg) which may be used for electrical energy and/or heat production.

The objectives of this study involved:

- Identification of the four remote communities that have the highest potentials for economically viable operation of biomass fuelled generating systems.
- Identification of the most appropriate method of biomass utilization (i.e. boiler/steam engine, boiler/turbine, gasifier/engine) for each of the study communities.
- Identification of the most appropriate methods of harvesting, processing and transporting biomass fuel to generating systems in each community.

Note:
* Under Energy Mines and Resources Canada's Remote Community Demonstration Program 41 communities are considered remote.

- Estimation of the cost per tonne* of biomass feedstock delivered to generating systems in each community.

- Estimation of the cost to install and operate biomass fuelled and diesel fuelled generating systems in each of the study communities.

COMMUNITY ASSESSMENTS

Evaluation of the 44** remote communities in northern Ontario resulted in identification of Armstrong, Fort Hope, Weagamow (Round Lake) and Gull Bay as those that have the highest potential for the economically viable operation of biomass fuelled generating systems. The locations of these communities are shown on Map 1.

Optimum Biomass Fuelled Generating Systems

The required electrical generating capacity and the optimum type of biomass fuelled generating system were identified for each community. These are indicated in Table 1.

TABLE 1

OPTIMUM BIOMASS FUELLED GENERATING SYSTEMS

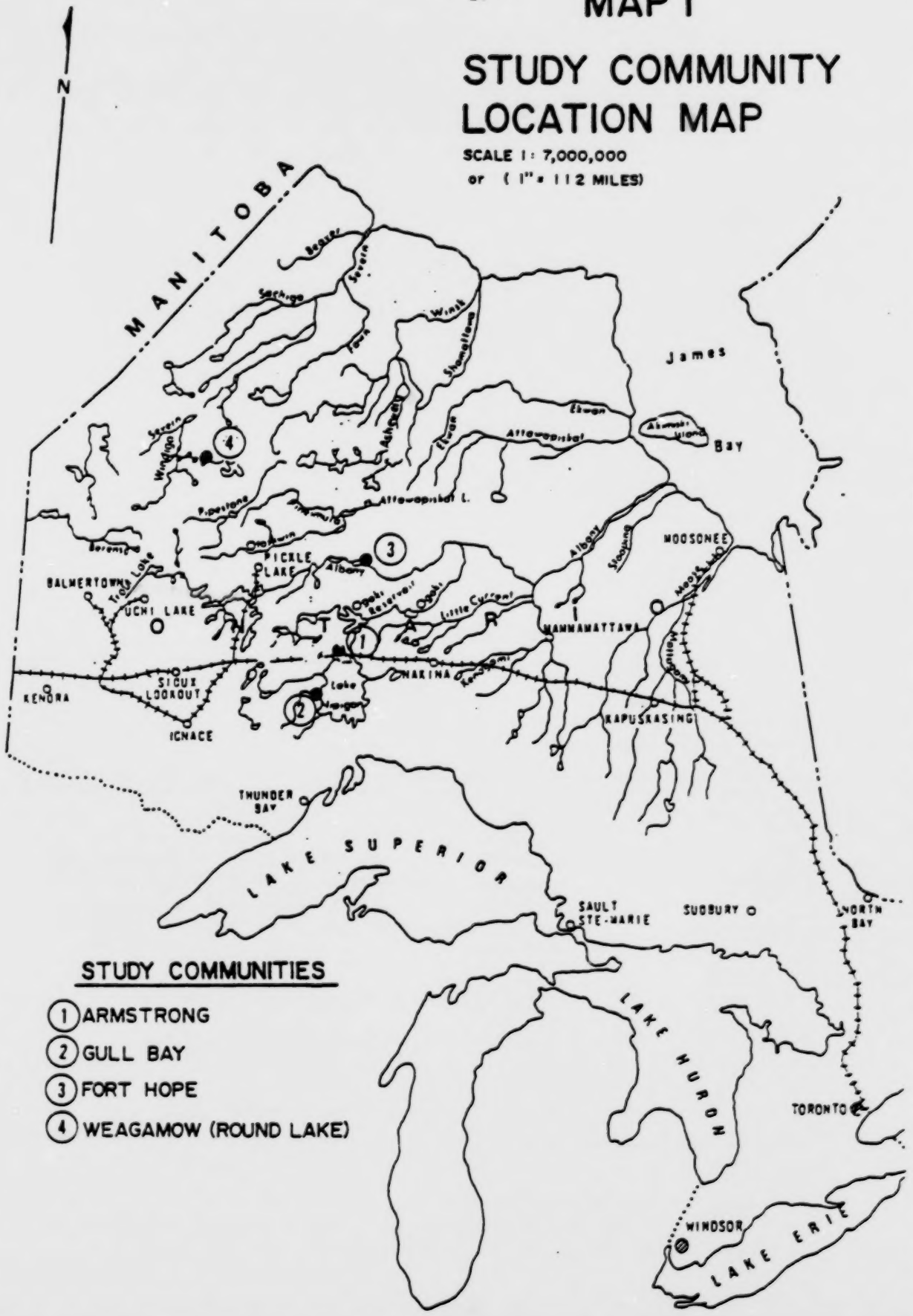
COMMUNITY	ELECTRICAL GENERATING CAPACITY (kilowatt)	OPTIMUM BIOMASS FUELLED GENERATING SYSTEM
Armstrong	1,000	Option 1: two-500 kw water tube boiler/steam turbines Option 2: A gasifier/dual fuel engine could be installed when successful demonstration of the technology has been completed and if this is determined to be an economically competative generating system for this community.
Fort Hope	500	two-250 kw fire tube boiler/steam engines
Weagamow (Round Lake)	300	two-150 kw fire tube boiler/steam engines
Gull Bay	200	one-200 kw fire tube boiler/steam engine

Notes:
* 1 tonne = approximately 2240 lbs.
** Under Energy Mines and Resources Canada's Remote Community Demonstration Program 41 communities are considered remote.

MAP I

STUDY COMMUNITY LOCATION MAP

SCALE 1 : 7,000,000
or (1" = 112 MILES)



Sources of Biomass

The types and sources of biomass which are available to each of the study communities are listed in Table 2.

The supply of wood biomass to Armstrong, Fort Hope, Weagamow and Gull Bay is technically viable using available forest harvesting technology.

TABLE 2

SOURCES OF BIOMASS

COMMUNITY	TYPE OF BIOMASS	LOCATION
Armstrong	wood	- salvage of residues and residual unmerchantable tree species from existing logging operations in the Armstrong area (i.e. Armstrong Crown, Domtar Inc. and Great Lakes Forest products Management Units).
	peat	- peatland located north of Armstrong airport, contains sufficient quality and quantity of fuel grade peat to satisfy energy requirements of community for approximately 22 years. - harvesting of this peat is not considered practical using existing dry mining technology*.
Fort Hope	wood	- more than sufficient volume available in fire-killed and over mature birch and poplar stands within the Reserve.
Weagamow	wood	- more than sufficient volumes identified (Round Lake) in three harvesting areas, within the Reserve, Crown Land east of Reserve, Crown Land southeast of Weagamow (Round) Lake.
Gull Bay	wood	- salvage of residues and residual unmerchantable tree species, from existing logging operations of the Kiashke River Native Development Inc. (Band owned, timber licence No. 363200) and adjoining timber licences of Domtar Inc. Great lakes Forest Products and Abitibi Price Forest Products.

* Note: Harvesting of this fuel peat may be practical when wet mining techniques have been developed for Canadian application.

Armstrong is the only study community for which the supply of peat as a source of biomass fuel was investigated. The supply of fuel peat from the peatland north of the airport, which is the optimum peatland in the area, does not appear to be feasible using available dry mining techniques.

Biomass Requirements

The biomass requirements of Armstrong, Fort Hope and Gull Bay, which exhibit potential for significant community expansion and/or economic development, were estimated based on two scenarios. Scenario 1 assumes normal growth of the community and scenario 2 assumes full development of potential community expansion and/or economic development opportunities. This provides a range of anticipated biomass requirements.

The biomass requirements of Weagamow (Round Lake) are based on normal growth of the community.

The biomass requirements contained in Table 3 are for the year indicated.

TABLE 3

BIOMASS REQUIREMENTS

COMMUNITY	1984 (Tonnes)	1988 (Tonnes)	1993 (Tonnes)	1998 (Tonnes)	2003 (Tonnes)
Armstrong					
Wood Biomass					
Scenario 1	10,854	11,503	12,375	13,320	14,354
Scenario 2	20,405	21,405	23,027	24,663	26,444
Fort Hope					
Wood Biomass					
Scenario 1	3,906	4,141	4,439	4,770	5,145
Scenario 2	10,612	11,359	12,304	13,358	14,551
Weagamow					
Wood Biomass					
Scenario 1	4,974	5,311	5,704	6,092	6,470
Gull Bay					
Wood Biomass					
Scenario 1	3,817	4,033	4,191	4,358	4,601
Scenario 2	5,350	5,566	5,724	5,891	6,134

More than sufficient quantities of wood biomass are available to satisfy the requirements of all of the communities on a sustained yield basis.

Biomass Harvesting, Transportation and Processing Methods

The optimum method of supplying wood biomass to generating systems in Armstrong and Gull Bay would consist of the year round salvage of residues and unmerchantable hardwood species from existing logging operations. The biomass would be chipped at the logging sites and delivered to the generating systems in dump trucks.

The optimum method of supplying wood biomass in Fort Hope and Weagamow would consist of summer and fall felling of fire-killed stands and overmature poplar and birch stands. The logs would be bucked in 6 to 7 m (20 to 23 ft) lengths for transport by sleighs on winter roads. Logs in excess of 24 cm (10 in.) diameter would be used for fuelwood or lumber and the remainder would be chipped at the generating site for use as biomass fuel.

The supply of wood biomass as a source of fuel is technically viable at all of the study communities using available technology.

ECONOMIC AND SOCIAL CONSIDERATIONS

Biomass Fuel Cost Estimates

Table 4 contains estimates of the cost of wood biomass delivered to generating systems in each of the study communities. The wood biomass would be in chip form suitable for use as fuel.

TABLE 4

BIOMASS FUEL COST ESTIMATES

YEAR	ARMSTRONG wood biomass cost/green tonne ($)	FORT HOPE wood biomass cost/green tonne ($)	WEAGAMOW wood biomass cost/green tonne ($)	GULL BAY wood biomass cost/green tonne ($)
1984	23.23	26.40	33.66	34.50
1988	29.04	33.00	42.08	43.13
1993	36.30	41.25	52.60	53.91
1998	45.38	51.56	65.75	67.39
2003	56.73	64.45	82.19	76.68

Note: Projections are based on an annual increase of 5%.
The costs shown are for the year indicated.

Biomass and Fuel Oil Cost Comparison

A comparison of the total estimated fuel oil and biomass costs and estimation of the net fuel savings, or losses (), which may result from use of biomass fuel in each community are contained in Table 5.

TABLE 5

BIOMASS AND FUEL OIL COST COMPARISON

COMMUNITY	YEAR	TOTAL FUEL OIL COST ($)	TOTAL BIOMASS FUEL COST	NET FUEL SAVINGS (losses) ($)
Armstrong				
Wood Biomass				
	1984	297,399	474,008	(176,609)
	2003	1,596,845	1,500,168	96,677
Fort Hope				
Wood Biomass				
	1984	303,187	280,157	23,030
	2003	1,714,026	937,812	776,214
Weagamow				
Wood Biomass				
	1984	87,138	167,425	(80,287)
	2003	452,046	531,769	(79,723)
Gull Bay				
Wood Biomass				
	1984	86,570	184,575	(98,005)
	2003	394,350	470,355	(76,005)

Note: Estimates of fuel requirements are based on full development of potential community expansion and economic opportunities.

Fuel oil cost projections are based on the 1984 cost of fuel oil in each community and the Ontario Ministry of Energy forecasts (Dec./83).

The costs shown are for the year indicated.

Estimates are listed for 1984, year five of the first five year period during which use of biomass fuel appears to be more economical than fuel oil, and 2003.

Fort Hope is the only study community at which use of wood biomass as fuel for electrical generation would presently result in a fuel cost

saving. In addition, potential exists for cogeneration for heating of buildings which may result in a saving of approximately $141,400 in displaced heating oil in 1984. This saving plus the potential $23,030 which may be saved in electrical generation results in a total savings of $164,430.

Generating Systems Capital Cost Comparison

The capital costs to install the optimum biomass fuelled and a comparable capacity diesel fuelled generating system in each of the communities were estimated. The generating capacity required, the optimum type of biomass fuelled generating system and the total cost and cost per kilowatt (kw) to install the biomass and diesel fuelled system are contained in Table 6.

TABLE 6

GENERATING SYSTEMS CAPITAL COST ESTIMATES

COMMUNITY	ELECTRICAL CAPACITY (kw)	OPTIMUM BIOMASS SYSTEM			DIESEL		ADDITIONAL COST FOR BIOMASS SYSTEMS	
		TYPE	COST/kw ($)	($000s)	COST/kw ($)	($000s)	COST/kw ($)	TOTAL ($000s)
Armstrong	1,000	steam turbine	4,900	4,900.0	1,729	1,729.0	3,171	3,171.0
Fort Hope	500	steam engine	A 3,850	1,925.6	2,128	1,060.0	1,722	856.6
			B 5,010	2,505.6	2,128	1,060.0	2,882	1,445.6
Weagamow	300	steam engine	4,610	1,383.5	2,660	978.0	1,950	585.0
Gull Bay	200	steam engine	4,880	976.0	2,925	585.0	1,955	391.0

Note: Cost estimates for the biomass systems include the costs of the power plant and generating system plus the costs of biomass harvesting; ---essing and transportation equipment and infrastructure which must be acquired to permit use of biomass as a fuel source.

Cost A for Fort Hope is for the biomass electrical generating system and excludes the cost of the cogeneration system. This is comparable to the cost of the systems at the other communities. Cost B is for the electrical generation and cogeneration systems.

For all of the study communities the cost to install a biomass fuelled generating system is greater than the cost to install a comparable capacity diesel generating system.

The additional cost per kilowatt (kw) to install the biomass as opposed to the diesel fuelled system is lower in Fort Hope than in any of the other study communities.

Generating Systems Operating and Maintenance Cost Estimates

The 1984 cost to operate and maintain the optimum biomass fuelled and comparable capacity diesel generating systems in each of the study communities were estimated. These estimates appear in Table 7.

TABLE 7

GENERATING SYSTEMS OPERATING AND MAINTENANCE COST ESTIMATES (1984)

		BIOMASS SYSTEM				DIESEL SYSTEM		
				OPERATION AND MAINTENANCE			OPERATION AND MAINTENANCE	
COMMUNITY	ELECTRICAL CAPACITY (kw)	TYPE	CAPITAL COST ($)	% CAPITAL COST	ANNUAL COST ($)	CAPITAL COST ($)	% CAPITAL COST	ANNUAL COST ($)
Armstrong	1,000	steam turbine	4,900,000	9	441,000	1,729,000	10	172,900
Fort Hope	500	steam engine	2,505,600	8	200,448	1,060,000	15	159,000
Weagamow	300	steam engine	1,383,500	8	110,680	798,000	13	103,000
Gull Bay	200	steam engine	976,000	7	68,320	585,000	12	70,200

Note: The percentages applied to capital costs take into account power plant staffing regulations and locations and size of systems.

The costs to operate and maintain the generating systems have been calculated as a percentage of the capital cost of the systems. The operation and maintenance percentage is generally lower for the biomass systems; however the capital cost is higher. As a result the operation and maintenance costs for the biomass systems are higher than those for the diesel systems in all of the study communities.

Employment Created

The number of people which may be employed and the wages created as a result of installation of a biomass fuelled generating system in each of the study communities are summarized in Table 8.

TABLE 8

EMPLOYMENT CREATED

COMMUNITY	BIOMASS SUPPLY	ENERGY PLANT STAFF	TOTAL	NUMBER OF PERSONS (YEARS)	WAGES
Armstrong	6	5	11	5.25	264,000
Fort Hope	14	5	19	13.3	227,600
Weagamow	14	5	19	14.0	302,360
Gull Bay	6	5	11	10.25	233,000

ADMINISTRATIVE FRAMEWORK

Table 9 contains a summary of the optimum administrative framework for supply of the biomass fuel and operation and maintenance of the generating systems at each of the study communities.

CONCLUSIONS

Of the 44* remote communities investigated, Fort Hope, Armstrong, Weagamow and Gull Bay, listed in order of descending potential, have the highest potentials for economically viable operation of biomass fuelled generating systems.

* Note: Under Energy Mines and Resources Canada's Remote Community Demonstration Program 41 communities are considered remote.

TABLE 9

ADMINISTRATIVE FRAMEWORK

COMMUNITY	SUPPLY OF BIOMASS FUEL	OPERATION AND MAINTENANCE OF GENERATING SYSTEM
Armstrong	- supply by existing forest harvest operators i.e. Great Lakes Paper Company, Domtar Inc. under contract to the system operator.	- Ontario Hydro
Fort Hope	- Band form business to conduct forest harvesting operations.	- Existing Fort Hope Power Authority
Weagamow	- Band form business to supply biomass fuel under contract to the system operator.	- Ontario Hydro
Gull Bay	- Kiashke River Native Development Inc. - Band owned forest harvesting operation supply biomass fuel under contract to system operator.	- Ontario Hydro

Sufficient sources of wood biomass are available within economical haul distances of these communities to permit supply of wood biomass fuel on a sustained yield basis.

The supply of wood biomass to each of the study communities is technically viable using available technology.

With the exception of Armstrong, fire tube boiler/steam engines are the optimum type of biomass fuelled generating system for the study communities. At present, water tube boiler/steam turbines appear to be the optimum system for Armstrong. However, a gasifier/dual fuel engine could be installed when successful demonstration of the technology has been completed and if this system is determined to be economically competitive.

The 1984 cost per green tonne of wood biomass fuel delivered to generating systems in each of the study communities was estimated to be $23.23 in Armstrong, $26.40 in Fort Hope, $33.66 in Weagamow, and $34.30 in Gull Bay. Generally, the cost per tonne of biomass decreases with an increase in the volume required.

Fort Hope is the only study community for which use of biomass fuel presently appears to be economically advantageous over use of fuel oil. The use of biomass fuel in Armstrong appears to be advantageous between the years 1998 and 2003. The use of biomass fuel does not appear to be advantageous in Weagamow or Gull Bay within the 20 year projection period of this study.

For all of the study communities the cost to install biomass fuelled generating systems is greater than that to install comparable capacity diesel fuelled systems. The additional cost per kilowatt is lowest in Fort Hope.

With the exception of Gull Bay, the operation and maintenance costs for biomass fuelled generating systems would be greater than for diesel fuelled systems. In Gull Bay, the costs would be comparable.

The installation of biomass fuelled generating systems would result in the creation of between 11 and 19 jobs which would generate between $227,000 and $402,000 in wages annually in each of the study communities.

The Ontario Ministry of Energy conducted a computer analysis, of the economic data for each of the four detailed study communities to determine the payback periods for the biomass fuelled generating systems. In the case of Fort Hope the revenue consisted of the potential fuel oil savings resulting from cogeneration (i.e. electrical generation and space heating) and revenue from an integrated forest harvesting operation (i.e. lumber and fuelwood). The payback period was calculated to be three years. For Armstrong, Weagamow and Gull Bay the revenue consisted of the fuel oil savings for electrical generation only. Payback on biomass fuelled systems installed in these three communities is not anticipated within the 20 year projection period of this study. The employment and resultant wages which may be created for the community members were not taken into consideration in these analyses.

RECOMMENDATIONS

The primary objective of this study involved the determination of the cost of biomass fuel delivered to generating systems in the study communities. In addition, some of the related economic considerations have been evaluated at a prefeasibility level. Prior to installation of a biomass fuelled generating system, a community specific detailed economic feasibility study should be conducted. This study should include: evaluation of the employment and wages created; the revenue which may be generated through development of an integrated forest harvesting operation (i.e. biomass, fuelwood and lumber); and the effect on Unemployment Insurance Commission and welfare transfers.

The lack of a coordinated policy for the investigation, installation, operation and maintenance of alternative energy supply systems in remote communities creates a barrier to the use of these systems. The government agencies responsible for energy supply in these communities should cooperate in the development of such policies.

Policies should also be established for the provision of incentives to encourage communities to pursue the installation of alternative energy systems where these systems are determined to be economical. These incentives may be in the form of wage subsidies for employment created or reduced power rates or increased levels of electrical service.

The appropriateness and economical viability of using biomass fuelled generating systems in remote communities are dependent upon a number of factors. Some of these factors are: the existing population; economic development and physical structure of the community; the anticipated population growth and economic development; the potential for cogeneration; the availability and cost of biomass fuel; interest of the community members; future cost of diesel fuel; and development of biomass energy systems technology. It is necessary to evaluate these and other factors to determine the appropriateness and economical viability of biomass fuelled generating systems for a particular community. However, it appears as if use of biomass fuelled generating systems may presently be economical in Fort Hope and may become economical in Armstrong between the years 1998 and 2003. Evaluation of the previously mentioned criteria may result in identification of other communities which exhibit similar appropriatness and economical viability to Fort Hope and Armstrong.

ÉVALUATION DE L'UTILISATION DES BIOCOMBUSTIBLES POUR LES COLLECTIVITÉS ÉLOIGNÉES DE L'ONTARIO

Résumé

Le présent rapport contient les constatations d'une étude entreprise pour déterminer la viabilité technique et le coût de l'alimentation en bois et en tourbe des centrales électriques dans quatre collectivités éloignées situées dans le nord de l'Ontario.

Les objectifs de l'étude sont: déceler les quatre collectivités offrant les meilleures possibilités pour l'exploitation rentable d'une centrale alimentée aux biocombustibles; déterminer les méthodes optimales d'utilisation de la biomasse (chaudière/machine à vapeur, chaudière/turbine, gazogène/moteur); déterminer les meilleures méthodes de récolte, de transformation et de transport de la biomasse; estimer le coût par tonne de la charge d'alimentation biomassique et estimer le coût d'installation des centrales électriques alimentées à la biomasse et au carburant diesel pour chaque collectivité.

Les collectivités considérées comme offrant les meilleures possibilités pour l'exploitation rentable d'une centrale alimentée aux biocombustibles, énumérées par ordre décroissant sont: Fort Hope, Armstrong, Weagamow (Round Lake) et Gull Bay.

Cinq chaudières tubulaires/turbines à vapeur avec puissance installée de 500, 300 et 200 kW respectivement ont été identifiées comme les centrales optimales alimentées à la biomasse pour Fort Hope, Weagamow et Gull Bay. Deux types de systèmes alimentés à la biomasse étaient identifiés comme appropriés pour fournir la puissance de 1000 kW requise à Armstrong; ce sont une chaudière aquatubulaire/turbine à vapeur ou un gazogène/moteur bicombustible. L'utilisation de gasogène/moteur bicombustible est possible seulement si la démonstration de la technologie et l'analyse économique ont été établies avec succès.

L'approvisionnement en bois semble viable sur le plan technique dans toutes les collectivités étudiées, et ce au moyen des techniques actuelles.

Armstrong est la seule collectivités qui a assez de tourbe. Cependant il ne serait pas possible d'assurer l'approvisionnement en tourbe par la mise en oeuvre des techniques actuelles d'extraction à sec.

Le coût estimé en 1984 pour le bois en tonne verte, livré aux centrales électriques des collectivités étudiées, est: Fort Hope 26,40 $; Armstrong 23,23 $; Weagamow 33,66 $; et Gull Bay 34,50 $.

Fort Hope a le plus grand potential pour l'exploitation rentable d'une centrale alimentées aux biocombustibles.

CHAPTER 1

INTRODUCTION

1.1 Background

The purpose of this study involves the investigation of peat and wood biomass as economically viable sources of energy supply for four remote communities in northern Ontario. Peat and wood biomass were investigated as potential sources of energy to supply all of the electrical and some of the space heating requirements of the communities. To accomplish this, it was necessary to determine the availability of sufficient quality and quantity of biomass (wood fibre or peat) and to estimate the cost per tonne of delivering the feedstock to biomass fuelled generating systems.

There are 44* communities in northern Ontario considered to be remote regarding their sources of energy supply. Remote communities are defined as areas of population containing more than ten permanent households which are not connected to a main electrical grid. Fossil fuels are the primary source of energy supply for these communities. Diesel generators are presently used to produce electrical power for the majority of communities and others do not presently have electrical service. Fuel oil or wood are used for space heating in the homes and commercial and institutional buildings. Propane, naptha and kerosene are also used for cooking, heating and lighting.

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* Note: Under Energy Mines and Resources Canada's Remote Community Demonstration Program, 41 communities are considered remote.

The costs for purchasing and transporting fossil fuels and maintaining the generating systems in the communities which have electrical service are rapidly increasing, as is the demand for electrical power in the communities which are not presently serviced. Consequently, the Ontario Ministry of Energy, with the support of Energy, Mines and Resources Canada, commissioned this study.

1.2 Objectives

This report contains the findings and recommendations of this study. The specific objectives of which were:

Phase I
- to select, from the 44* remote communities, those communities which exhibit the best opportunities for economically viable operation of biomass fuelled electrical generating and/or heating systems.
- to identify the fuelwood and peat and wood biomass resources** in proximity to the above communities and any land use or social constraints to utilization of the biomass resources. The peat resources of two and the wood biomass resources of four communities were investigated.
- to recommend the four communities which exhibit the best opportunities for economically viable operation of biomass fuelled generating systems.

Phase II
- to identify the optimum method of biomass utilization (i.e. boiler/steam engine, boiler/turbine, gasifier/duel fuel engine) for each of the four communities.
- to identify the most appropriate administrative framework and methods for harvesting, transporting and processing of the biomass feedstock.
- to estimate the cost per tonne of feedstock delivered to biomass fuelled generating systems in the four communities.

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* Note: Under Energy Mines and Resources Canada's Remote Community Demonstration Program, 41 communities are considered remote.

** Note: Fuelwood refers to wood harvested for use in home heating and cooking. Biomass refers to wood biomass or peat harvested for use as feedstock in electrical generating or heating systems.

1.3 Approach

This section of the report briefly describes the methods used to achieve the study objectives.

Available maps and publications were reviewed and discussions were held with persons familiar with conditions at the remote communities.

A matrix was developed to rate the potential for economically viable operation of a biomass fuelled generating system at each community. The six communities exhibiting the highest potentials for economically viable operation of biomass fuelled generating systems were identified.

The biomass resources of these six communities were mapped using available information, aerial photographs, and reconnaissance level field investigations. Data were obtained regarding the existing and anticipated structure and energy requirements of the communities. Interviews with community representatives were conducted to assess the interests and skills of the community members pertinent to the use of biomass as a source of energy supply. The suitability of the six communities for economically viable operation of biomass fuelled generating systems was evaluated and the four communities exhibiting the highest potentials were identified.

The most appropriate type of biomass fuelled generating system (i.e. boiler/steam engine, boiler/turbine, gasifier/duel fuel engine) was identified for each of the four communities.

Field investigations were conducted at the four communities to obtain additional data regarding the location, quality

and quantity of the biomass resources.

Meetings were conducted to explain the basic principles of biomass fuelled generating systems to the community members and to obtain additional data regarding the skills and interests of the work force, labour costs, availability and condition of equipment, etc.

The most cost effective administrative framework and methods for harvesting, transporting, and processing the biomass feedstock were identified. The cost per tonne for biomass feedstock delivered to a generating system in each of the communities was estimated.

The energy requirements of each of the four communities were projected to the year 2003. The capacities of generating systems capable of satifying these requirements were determined and costs of installing biomass and diesel fuelled generating systems in each of the four communities were estimated.

The Ontario Ministry of Energy conducted a computer analysis of the economic data for each of the detailed study communities to determine the payback periods for biomass energy systems installed in these communities. Copies of the computer print outs for each community are contained in Appendix C.

1.4 Scope

The large number of remote communities to be investigated during this study necessitated a preliminary ranking and selection of the study communities based on review of available data and discussions with persons familiar with the communities. Study effort was thus concentrated on

those communities exhibiting the highest potentials and greatest demand for the installation of biomass fuelled generating systems.

The reconnaissance field investigations conducted during Phase I were designed to verify available information and to provide preliminary data regarding the quality and quantity of biomass resources at six study communities. Detailed field investigations conducted during Phase II provided estimates of quality and quantity of biomass available; identification of optimum methods of harvesting, processing and transporting the biomass; and estimation of cost per tonne of biomass feedstock delivered to the generating systems.

Individual, community specific generating system design and/or cost estimating are outside the scope of this study. Prefeasibility estimates of the cost to install biomass and diesel fuelled generating systems were prepared through identification of the optimum types of biomass fuelled generating systems, the anticipated future energy requirements, review of available reports and discussions with manufactures and installers of these systems.

1.5 Structure of Reports

A Phase I report was prepared by Bird and Hale Ltd. in July, 1984. That report contains the observations, conclusions and recommendations of Phase I of this study. The base data used to evaluate the remote communities, selection of six reconnaissance level study communities, identification of four detailed study communities and identification of appropriate generating systems for these communities are contained in the Phase I report.

This final report contains a summary of information set out

in the Phase I report, results of investigations at four detailed study communities, estimates of cost per tonne for feedstock delivered to biomass fuelled generating systems, and cost estimates for the installation of biomass and diesel fuelled generating systems at each community.

CHAPTER 2

STUDY COMMUNITIES

2.1 Remote Study Communities

The communities included in the list of "Remote Communities in Ontario" as contained in the Remote Community Data Base, Volume 1 prepared by Ralph Hedlin Associates, September 1982 were considered during this study. Mud River was also added to this list.

Figure 1 contains the list of these communities and the location of each is indicated.

2.2 Reconnaissance Level Study Communities

The six communities listed in Figure 2 were identified as those having the highest potentials for economically viable operation of biomass fuelled generating systems.

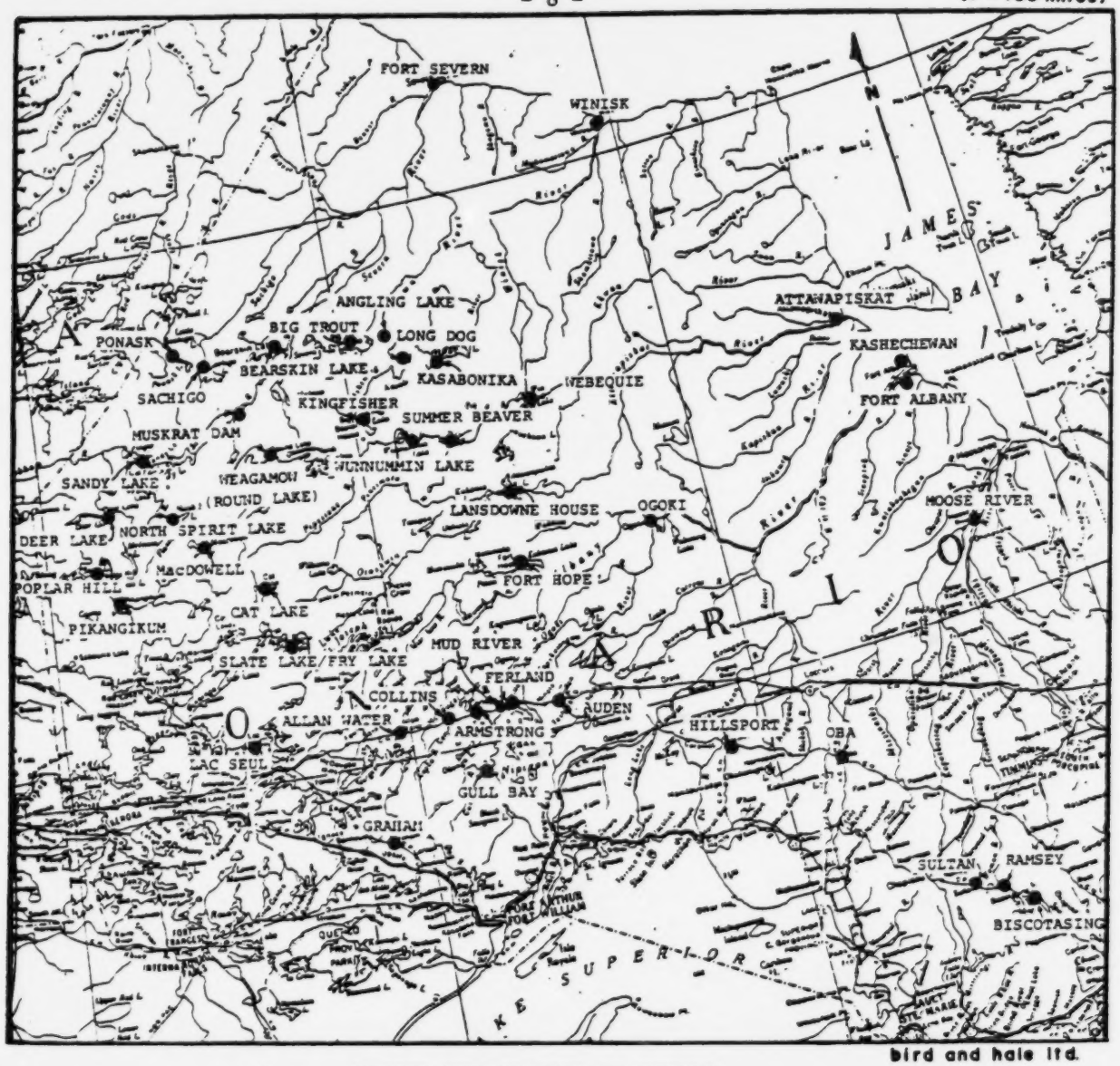
The rating system used in Figure 2 is explained in Appendix A. The Phase I Report contains the rating matrix for all of the 44 remote communities. This matrix includes ratings and comments for each community for the various evaluation criteria.

Recommended replacement study communities were also identified. Thus, if during field investigations one or more of the communities was deleted for some reason replacements would be available.

Data obtained during reconnaissance level field investigations permitted a more detailed evaluation of the potential of six communities for economically viabl operation of biomass fuelled generating systems. A summary

REMOTE COMMUNITY LOCATION MAP

SCALE 1: 6,336,000
(1" = 100 miles)



bird and hale ltd.

REMOTE COMMUNITIES IN ONTARIO

Oba
Fort Albany
Moose River
Angling Lake
Attawapiskat
Bearskin Lake
Big Trout
Cat Lake
Deer Lake
Fort Hope
Fort Severn
Kasabonika
Kashachewan
Kingfisher
Lac Seul
Lansdowne House
Long Dog
MacDowell
Muskrat Dam
North Spirit Lake
Ogoki
Pikangikum
Ponask
Poplar Hill
Sachigo
Sandy Hill
Slate Lake/Fry Lake
Summer Beaver
Weagamow (Round Lake)
Webequie
Winisk
Wunnummin Lake
Biscotasing
Sultan
Ramsey
Allan Water
Armstrong
Auden
Collins
Ferland
Graham
Gull Bay
Hillsport
Mud River

NOTE: Long Dog, MacDowell and Ponask are not eligible under the Remote Community Demonstration Program (E.M.R.)

FIGURE 2

RECONNAISSANCE LEVEL
STUDY COMMUNITIES

COMMUNITY	COMBINED RATING WOOD FIBRE (WOOD FIBRE POTENTIAL) MAX. POSS. 15 (MAX. POSS. 5)	COMBINED RATING PEAT (PEAT POTENTIAL) MAX. POSS. 15 (MAX. POSS. 5)	RECOMMENDED FEEDSTOCK
Armstrong	14 (5)	13 (4)	wood/peat
Gull Bay	13 (5)	11 (3)	wood
Fort Hope	13 (5)	11 (3)	wood
Bearskin Lake	13 (5)	10 (2)	wood/peat
Weagamow	12.5 (4)	9.5 (1)	wood
Collins	12 (5)	10 (3)	wood
	RECOMMENED REPLACEMENT STUDY COMMUNITIES		
Webequie	11 (4)	8 (1)	wood
Kingfisher	10.5 (5)	6.5 (1)	wood

of the results of this evaluation and an explanation of the rating system used are contained in Appendix A.

2.3 Detailed Study Communities

Of the six communities investigated at the reconnaissance level the following four, listed in order of descending potentials, were identified as having the highest potentials for economically viable operation of biomass fuelled generating systems.

Armstrong
Fort Hope
Weagamow (Round Lake)
Gull Bay

Results of the detailed evaluation of the suitability of these communities for economically viable installation of biomass fuelled generating systems are contained in Chapters 3 to 7 of this report.

CHAPTER 3

ARMSTRONG

3.1 Opportunities and Constraints of a Biomass Fuelled Generating System

The following is a brief description of the major opportunities and constraints to economical operation of a biomass fuelled generating system in Armstrong.

Opportunities

There is potential for the creation of 11 permanent jobs in the harvesting and processing of wood biomass and staffing of the energy plant. This would represent a total of approximately $264,000 in wages in 1984.

Conditions are suitable for the installation of a biomass fuelled electrical generating system of the boiler/steam turbine type.

There is a partially developed system to produce wood biomass feedstock, from both residues and presently un-utilized species from the existing forest harvesting operations.

The cost of wood biomass is low.

Opportunity exists for demonstration of a generating system fuelled by either wood or peat biomass.

The potential economic benefits appear to be good due to presently high electrical rates, relative to communities that are connected to the main electrical grid, potential economic and community development, and the relatively low

cost of biomass fuel.

There is an immediate demand for additional electrical power to satisfy the requirements of the Armstrong area.

Constraints

The community lacks a local government organizational structure to coordinate construction and operation of a generating system.

An agency was not identified that has a mandate to provide capital or operating funding.

3.2 Optimum Biomass Fuelled Generating System

The total electrical capacity required at Armstrong is estimated to be 1,000 kw; this should be produced by two-500 kw generating units. (See section 3.4 for details of capacity required.) It is assumed that the existing diesel units would be maintained and used for standby.

Conditions are suitable for the installation of either a water tube boiler/steam turbine or a gasifier/dual fuel engine. Installation of a gasifier/dual fuel engine could be undertaken after the technology has been successfully demonstrated and if this is determined to be an economically competative generating system for this community.

At this time two - 500 kw steam turbines appear to be the optimum generating system for this community.

A schematic diagram of the optimum wood biomass cogeneration system is contained in Appendix AR-1. Appendices AR-2 and AR-3 contain diagrams and specifications of typical high pressure water tube boilers and steam turbines.

3.3 Source of Biomass

Wood Biomass

The production of wood biomass would be based upon the salvage of residues and residual unmerchantable tree species from cut-over areas.

It is estimated that between 25 and 35% of wood fibre is left as residues on logging sites in the Armstrong area. These residues consist of logging slash, dead and dying unmerchantable trees and residual tree species (poplar, white birch).

The Armstrong management unit and Domtar W.C. are expected to yield 164,705 merchantable green cunits* of wood fibre per year for the next 20 years. This would result in a volume of 81,600 tonnes of residues per year that may be used as biomass feedstock. This information is contained in a letter from Domtar Inc., that is included as Appendix AR-4. This volume represents three times the estimated volume required to supply power to the Armstrong core, D & L Estates and the Whitesand Indian Band in the year 2003.

Peat

The results of detailed evaluation of Peatland No.1, that is located north of the Armstrong airport, are contained in the Phase I report. The results of laboratory analysis, of peat samples obtained from this peatland are contained in Appendix AR-5.

The northwest portion of the peatland, that contains the majority of fuel peat, is elevated approximately 14 m above Jojo Lake. A drainage ditch constructed from the east portion of the peatland to this lake appears to be the only

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* Note: 1 cunit contains 100 cubic ft. of solid wood.

practical drainage outlet from the peatland. However this would require the excavation of approximately 3,700 m. of primary drainage ditch. This length of ditch constructed with only a 14 m elevation difference would have less than 0.5% grade. This grade is insufficient to permit drainage of the peatland. In addition construction of this ditch would require a maximum cut of approximately 8 m in saturated fine sand. The cost and engineering difficulties associated with this are considered to render the undertaking impractical.

The potential for siltation and detrimental impact to the water quality of Jojo Lake and the Whitesand River may result in impact on the trout fishery which is reported to exist in this drainage system (Ministry of Natural Resources).

It is anticipated that the cost of assessing the potential for environmental impact, the resultant mitigating measures, and the previously mentioned costs and engineering difficulties render the development of this peatland impractical using available dry mining techniques. However, development of this peatland may be feasible in the future using wet mining technology.

The peatland located north of the Armstrong Airport is estimated to contain $2.6 \times 10^6 m^3$ of fuel grade peat which may be harvested when suitable technology is developed. At 50% moisture content this represents approximately 450,000 tonnes of fuel peat. This is in excess of the estimated 392,400 tonnes of fuel peat which would be required to supply the Armstrong core, D & L Estates, and the Whitesand Indian Band to the year 2003.

3.4 Biomass Requirements

Wood Biomass

It is estimated that approximately 20,000 tonnes of wood biomass would be required to produce the 3.8 million kwh of power necessary to satisfy the demand of the Armstrong core community, D & L Estates and Whitesand Indian Band in 1984.

Figure 3 contains projections of the future power and wood biomass requirements, under two different scenarios to the year 2003. Scenario 1 assumes supply of power to the Armstrong core community only and Scenario 2 assumes supply of power to the Armstrong core, D & L Estates and the Whitesand Indian Band.

Peat

It is estimated that approximately 17,000 tonnes of fuel peat (50% moisture content) would be required to produce the power necessary to satisfy the demand of the Armstrong core, D & L Estates and the Whitesand Indian Band in 1984. Figure 3 contains projections of the future power and fuel peat requirements under the two previously described scenarios.

3.5 Biomass Harvesting Transportation and Processing Methods

Wood Biomass

The wood biomass harvesting and transportation system should consist of the following:

a) Chip Harvesting - with Timberjack Forwarder
   B.D.R./Bruks 1001 CT - Chip Harvester (see Appendix AR-6)
   B.D.R./Bruks 1001 CT - Trailer Chipper (see Appendix AR-6)

Chip harvesting will consist of harvesting of logging residues and residual trees at stump and roadside. The trailer chipper will be used at roadside and bunker. This will permit small scale logging operators to produce chips.

FIGURE 3

PROJECTED WOOD AND PEAT BIOMASS REQUIREMENT

SCENARIO 1

YEAR	POP.	PERCENT. GROWTH	POWER CONSUMPTION (kwh)	PARASITIC LOAD (kwh)	TOTAL LOAD (kwh)	WOOD BIOMASS REQUIREMENT (tonnes)	PEAT REQUIREMENT (tonnes)
1984	500	0.0	1,610,000	438,000	2,048,000	10,854	9,195
1988	541	7.6	1,732,360	438,000	2,170,360	11,503	9,745
1993	598	9.5	1,896,934	438,000	2,334,934	12,375	10,484
1998	660	9.4	2,075,245	438,000	2,513,245	13,320	11,284
2003	728	9.4	2,270,318	438,000	2,708,318	14,354	12,160

Note:

Population: Armstrong Core

Power Requirement: Armstrong (existing)

Parasitic Load*: 50 kw x 8760 hrs/yr = 438,000 kwh

Wood Biomass Requirement: 5.3 kg/kwh for this generating system taking into consideration 70% boiler and 14% steam turbine efficiencies. The biomass requirement is for the year shown.

SCENARIO 2

YEAR	POPULATION	PERCENTAGE GROWTH	POWER CONSUMPTION (kwh)	PARASITIC LOAD (kwh)	TOTAL LOAD (kwh)	WOOD BIOMASS REQUIREMENT (tonnes)	PEAT REQUIREMENT (tonnes)
1984	850	0.0	2,974,000	876,000	3,850,000	20,405	17,287
1988	915	7.1	3,185,154	876,000	4,061,154	21,524	18,235
1993	1,004	8.9	3,468,633	876,000	4,344,633	23,027	19,507
1998	1,102	8.9	3,777,341	876,000	4,653,341	24,663	20,894
2003	1,210	8.9	4,113,524	876,000	4,989,524	26,444	22,403

Note:

Population: Armstrong core + D & L Estates and Whitesand Indian Band

Power Consumption: Ontario Hydro, D & L Estates and Whitesand Indian Band

Parasitic Load*: 100 kw x 8760 hrs/yr = 876,000 kwh

Biomass Requirement: 5.3 kg/kwh for this community taking into consideration 70% boiler and 14% steam turbine efficiencies. The biomass requirement is for the year shown.

Peat Requirement: 4.5 kg/kwh with above considerations.

*Note: Parasitic load is defined as the energy consumed within a boiler house and for auxiliary uses (lights, fans, etc.) which are required to support the energy system. Parasitic load does not increase significantly with power consumed.

All biomass will be fully chipped in the field. The forest biomass will be in the form of standard pulp chips with a moisture content varying from 35 to 50%.

b) The transportation system will consist of three dump trucks which will deliver the biomass to a storage bunker at the generating system. The biomass will be retrieved from the bunker by a push-rod system feeding into a vibrator conveyor with a built-in screen. From the vibrating conveyor the biomass will be pnuematically blown to the green biomass combustion/boiler.

The total estimated capital cost of the harvesting and delivery equipment is $555,000. Details of this cost estimate are contained in Appendix AP-8.

Peat

As previously mentioned development of the primary peatland in the area using available dry mining techniques does not appear to be practical; however this peatland has been used as a case study in the cost of harvesting peat in northern Ontario using dry mining techniques. Peatland preparation and harvesting procedures that would be used are outlined in Appendix AR-9.

Total estimated cost of the dry mining harvesting, processing and delivery equipment and related infrastructure i.e. peat storage facilities, electrical power supply etc., is $1,674,350. Details of this cost are contained in Appendix AR-10.

3.6 Economic and Social Considerations

i) Biomass Fuel

This section of the report contains estimates of the cost of biomass feedstock delivered to the generating system,

projections of this cost to the year 2003, projections of the fuel oil cost, comparisons of the biomass and fuel oil projections and estimates of net fuel saving that may result from use of biomass fuel.

Wood Biomass

The cost per green tonne for harvesting and delivery of wood biomass in 1984 is estimated at $23.23. Appendix AR-11 contains details of the costs for harvesting and delivery of wood biomass to the generating system.

The following is a projection of the wood biomass cost per tonne to the year 2003. This projection is based on an annual cost increase of 5%.

FIGURE 4

PROJECTED WOOD BIOMASS COST

YEAR	WOOD BIOMASS COST PER TONNE ($)
1984	23.23
1988	29.04
1993	36.30
1998	45.38
2003	56.73

Fuel Peat

As previously mentioned development of the peatland north of the Armstrong airport does not appear to be feasible using available dry mining technology. However the cost of harvesting fuel peat from this peatland using this

technology has been calculated as a case study in dry mined fuel peat costs in northern Ontario. Indications are that the costs of harvesting and processing of peat using wet mining techniques will be similar to those using dry mining. A drainage outlet ditch length of 500 metres was used and it was assumed that a reasonable amount of investigation would be required to identify environmental concerns, design mitigating measures and obtain environmental approvals.

The cost per tonne of fuel peat (50% moisture content) harvested and delivered to a generating system in Armstrong is estimated to be $20.70 per tonne (1984 dollars). This estimated cost is exclusive of royalties which will likely be required for peat extracted from Crown Land. The Ministry of Natural Resources has not established a royalty structure for peat extraction, however, a provincial government committee has been formed to establish a fee structure. As an indication of the fee which may be charged the present royalty for granular material is $.30 per tonne and for wood biomass the fee is $.66 per tonne. Assuming an average of these two fees is charged the total 1984 cost per tonne of peat delivered would be approximately $21.20 per tonne at 50% moisture content. Details of this cost estimate are contained in Appendix AR-10.

The following is a projection of the fuel peat cost per tonne (dry mined) to the year 2003. This projection is based on an annual cost increase of 5%.

FIGURE 5

PROJECTED FUEL PEAT COST

YEAR	FUEL PEAT COST PER TONNE ($)
1984	20.70
1988	25.88
1993	32.35
1998	40.44
2003	50.55

Note: costs do not include provincial government royalty for peat extracted from Crown Land as fee rate not established; rate may be approximately $.50 per tonne.

ii) Fuel Oil

The following fuel oil price forecasts are based on scenario 2 in which power is supplied to the Armstrong Core, D & L Estates and the Whitesand Indian Band.

FIGURE 6

PROJECTED FUEL OIL COST

YEAR	ESTIMATED POWER CONSUMED (kwh)	ESTIMATED FUEL OIL REQUIREMENT (l)	ESTIMATED FUEL OIL PRICE ($/l)	ESTIMATED FUEL OIL COST ($)
1984	2,974,000	991,330	0.30	297,399
1988	3,185,000	1,061,660	0.39	414,047
1993	3,468,633	1,156,210	0.58	670,601
1998	3,777,341	1,259,110	0.82	1,032,470
2003	4,113,524	1,371,170	1.15	1,576,845

Note:

Estimated Fuel Oil Requirement: based on production of 3.0 kwh per litre of fuel oil

Estimated Fuel Oil Cost (Savings): based on 1984 price of fuel oil in Armstrong, of: $.30/l and Ontario Ministry of Energy Forecasts (Dec.'83).

iii) Fuel Cost Comparison

The following fuel cost comparisons are based on scenario 2 in which power is supplied to the Armstrong Core, D & L Estates and the Whitesand Indian Band.

FIGURE 7

WOOD BIOMASS AND FUEL OIL COST COMPARISON

YEAR	WOOD BIOMASS REQUIREMENT (tonnes)	TOTAL WOOD BIOMASS COST/TONNE ($)	WOOD BIOMASS COST ($)	TOTAL FUEL OIL COST ($)	NET FUEL SAVINGS ($)
1984	20,405	23.23	474,008	297,399	(176,609)
1988	21,524	29.04	625,056	414,047	(211,009)
1993	23,027	36.30	835,880	670,601	(165,279)
1998	24,663	45.38	1,119,206	1,032,470	(86,736)
2003	26,444	56.73	1,500,168	1,576,845	76,677

Notes:

Wood Biomass cost per tonne: based on an annual increase of 5%

Fuel Oil Cost: Based on a 1984 fuel price of $.30/l and Ontario Ministry of Energy Forecasts (Dec.'83).

( ): Indicate net loss.

FIGURE 8

FUEL PEAT AND FUEL OIL COST COMPARISON

YEAR	PEAT REQUIRED (tonnes)	PEAT COST/TONNE ($)	TOTAL PEAT COST ($)	TOTAL FUEL OIL COST ($)	NET FUEL SAVINGS ($)
1984	17,287	20.70	357,840	297,399	(60,441)
1988	18,235	25.88	471,920	414,047	(57,873)
1993	19,507	32.35	631,050	670,601	39,551
1998	20,894	40.44	844,953	1,032,470	187,517
2003	22,403	50.55	1,132,471	1,576,845	444,374

Notes:

Peat cost per tonne: Based on an annual increase of 5%

Fuel oil cost: Based on a 1984 fuel price of $.30/l and Ontario Ministry of Energy Forecasts (Dec.'83)

iv) Generating Systems Capital Cost Estimates

a) Wood Biomass Fuelled Generating System

The total estimated capital cost to install wood biomass fuelled generating system is $4,350,000. Appendix AR-8 provides the estimated cost for various types of machinery and equipment required.

In addition to the above cost the estimated $550,000 capital cost for the wood biomass harvesting and delivery equipment results in a total cost of $4,900,000 for complete wood biomass system.

b) Peat Fuelled Generating System

Considering peat mining techniques which are available peat does not appear to be a feasible source of biomass fuel for Armstrong at this time. Therefore a capital cost estimate for a peat fuelled generating system has

not been prepared. However, the cost for a peat fuelled generating system should be similar to that for a wood biomass fuelled system.

c) Diesel Fuelled Generating System

Based on discussions with private contractors and personnel with Ontario Hydro, 1984 installation cost for a diesel generating system of the required 1,000 kw capacity is estimated to be $1,729,000.

v) Employment Created

The increased availability of electrical power, that would result from installation of a 1,000 kw system in Armstrong, may stimulate economic development. However, present relatively high electrical rates are a major constraint to economic development and community expansion. The prospects are poor for significant economic development unless these rates are reduced.

Economic benefits in the form of employment created may result from installation of a biomass fuelled generating system as described below.

Wood Biomass Fuelled Generating System

Based on Scenario 2 it is estimated that a total of 11 persons would be employed in the harvesting and processing of wood biomass and staffing of the energy plant in 1984. This represents a total of approximately $264,000 in wages.

Details of the types and numbers of jobs created are contained in Appendix AR-12.

Peat Biomass Fuelled Generating System

Based on scenario 2 it is estimated that a total of 24 persons would be employed in the harvesting and processing of peat in 1984. This would consist of 19 persons employed for a six month season in the delivery of feedstock and 5 persons employed year round to staff the energy plant.

As peat does not appear to be a feasible fuel source at this time, wages created have not been calculated.

vi) Economic Analysis

The economic analysis conducted by the Ontario Ministry of Energy indicates a rate of return of -1.88 per year and reveals that payback on a biomass fuelled generating system would not occur within the 20 year projection period of this study. This analysis was based on economic data acquired during this study and the wages that may be created for the community members was not inlcuded as revenue from the system. Details of this analysis are contained in Appendix AR-13.

3.7 Environmental Impact

Wood Biomass

No environmental impacts will result directly from the harvesting of logging residues, dead or dying trees and unmerchantable hardwoods for use as biomass feedstock. Biomass harvesting will directly follow the logging of merchantable softwood pulp and sawlogs.

At the discretion of the Ministry of Natural Resources, sensitive forest sites with soils requiring slash protection will be by-passed. Residues and residual tree removal will in most cases aid silviculture and reforestation practices.

Peat

The general types of potential environmental impacts which may result from the development of a peat deposit are outlined in the Phase I report.

Discussions with Ministry of Natural Resources personnel in Armstrong and Nipigon revealed the following potential environmental impacts. The primary peatland, that is located north of the Armstrong airport, is in the vicinity of a caribou wintering ground, however the peatland is not considered to be part of this wintering ground. The Whitesand River is reported to support an important trout fishery. This drainage system would receive any water outlet from the peatland. Assessment of the potential for detrimental impact to the water quality of this drainage system and any necessary mitigating measures would be costly and may preclude development of the peatland using available dry mining techniques.

3.8 Administrative Framework

a) Biomass Generating System

Ontario Hydro has the jurisdiction and responsibility of supplying electrical power to the Armstrong community. The proposed 1000 kw biomass generating system could be maintained under the present mandate of Ontario Hydro. However, various alternatives could be considered for the ownership and operation of the proposed energy system.

These are as follows:

1. Private or community ownership of the energy plant with contract to sell parallel power to Ontario Hydro.

2. Ownership by Ontario Hydro with subsequent sub-contracting for the harvesting, transportation and

processing of the biomass fuel.

3. A joint venture between private industry and local government or Federal and Provincial Ministries and Ontario Hydro, for the construction and operaton of a biomass system.

b) Biomass Harvesting, Transportation and Delivery

Wood Biomass

The Great Lakes Paper Co. and Domtar Inc. have the long-term lumber supply commitments in the Armstrong Region. These commitments include the ownership and allocation of wood biomass fuels such as logging residues, salvage timber and unmerchantable forest stands. The optimum framework for supply of the wood biomass feedstock would be for one of the previously mentioned companies to harvest, process and deliver the feedstock to the generating system under contract to the generating system operator.

Peat

When peat wet mining techniques have been proven feasible for Canadian application, development of the peatland north of the Armstrong airport should be reconsidered. Should development be determined feasible the optimum framework for the supply of peat feedstock would be for a private contractor to harvest, process and deliver the feedstock to the generating system under contract to the generating system operator.

3.9 Conclusions

Sufficient sources of wood biomass are available to satisfy the requirement of the community on a sustained yeild basis.

Relatively low cost wood biomass is available from residues and tree species which are presently not utilized by the existing forest harvesting operations.

The cost per green tonne for harvesting and delivery of wood biomass in 1984 is estimated to be $23.23.

The optimum biomass fuelled generating system would consist of two-500 kw water tube boiler/steam turbines. A gasifier/dual fuel engine may be considered after the technology has been successfully demonstrated and if this is determined to be an economically competetive generating system for this community.

The preliminary economic analysis, conducted by the Ontario Ministry of Energy, reveals that payback on a biomass fuelled generating system would not likely occur within the 20 year projection period of this study.

There was potential for employment of 11 persons, representing approximately $264,000 annually in wages, in the harvesting and processing of wood biomass and staffing of the energy plant in 1984.

Should a biomass fuelled generating system be installed it is recommended that it be maintained under the present mandate of Ontario Hydro. The optimum method for supply of the wood biomass feedstock would be delivery, on contract, by one of the existing logging companies to the system operator.

CHAPTER 4

FORT HOPE

4.1 Opportunities and Constraints of a Biomass Fuelled Generating System

The following is a brief description of the major opportunities and constraints to economical operation of a biomass fuelled generating system in Fort Hope.

Opportunities

Of the communities investigated, Fort Hope has the best undeveloped forest resources.

It exhibits the best opportunity for economically viable operation of a biomass fuelled boiler/steam engine system.

The community is presently operating and maintaining a diesel generating and electrical distribution system under the Fort Hope Power Authority. The community would have jurisdiction to operate and maintain a biomass fuelled system.

Large scale community expansion is proposed for the near future.

Potential exists for cogeneration with the proposed community expansion.

Band leadership and administration are strong and well organized.

There was potential in 1984 for a total fuel saving of approximately $164,438. Projected to the year 2003 this

represents a saving of approximately $1,801,443 per year.

There is potential for employment of 17 persons in the harvesting, processing, and transportation of biomass and operation of the generating system. This employment would result in approximately $265,000 in wages for the community members (1984).

Community members are very interested in biomass energy technology, particularly as it relates to reduced energy production costs, employment creation, and economic development.

Potential exists for development of an integrated forest harvesting operation to produce fuelwood, biomass fuel and sawlogs.

An agency was not identified that would provide the capital and operating funds for a biomass fuelled generating system.

Constraints

All weather road and rail access are not available. However, a winter cat track from Pickle Lake, which is maintained by the Band Council, can be utilized when demand and conditions warrant.

4.2 Optimum Biomass Fuelled Generating System

Two fire tube boiler/steam engines, capable of producing 250 kw of power each, are the optimum biomass fuelled generating systems for this community. (See section 4.4 for details of the capacity required.)

It is assumed that the existing diesel units would be maintained and used for standby.

A schematic diagram of the proposed system is contained in Appendix FH-1. Appendices FH-2 and FH-3 contain data regarding possible boiler and steam engine specifications.

The proposed energy system would supply the full requirements for electrical power in the community and the heating requirement for all proposed institutions and commercial establishments. Newly constructed housing developments adjacent to the hot water supply lines could be connected for space heating and hot water supply. Appendix FH-4 indicates the area of proposed community expansion and proposed locations of the generating system and cogeneration, including water heating and electrical hookup lines.

4.3 Source of Biomass

Wood Biomass

The total volume of wood biomass required by Fort Hope over the next 20 year period, assuming the proposed community expansion occurs, will be approximately 248,000 tonnes. As indicated in the Phase I Report, in excess of this volume of wood biomass has been identified in fire-killed and overmature poplar and birch stands within the Reserve.

Peat

Preliminary investigations indicated that the potential is low for use of peat as a source of biomass fuel for this community. Therefore, detailed investigations were not conducted.

4.4 Biomass Requirements

Assuming that the proposed community expansion is undertaken in 1984, approximately 10,600 tonnes of wood biomass would be required to produce the 1.5 million kwh of power

necessary to satisfy the demand of the community.

Figure 9 contains projections of the future power and resultant biomass requirements, under two different scenarios, to the year 2003. Scenario 1 assumes normal growth of the existing community. Scenario 2 is based on growth of the existing community plus full development of the proposed community expansion plans including a new school, recreation facilities, housing development, and forest harvesting operations.

4.5 Biomass Harvesting, Transportation and Processing Methods

Wood Biomass

The production of wood biomass at Fort Hope would be totally integrated with the production of sawlogs and fuelwood.

Forest harvesting during will initially take place in a large area of fire-killed timber located approximately 5 km northeast of the community. A winter road system would gradually be extended to the eastern boundary of the Reserve.

Harvesting will be extended over a six-month period as follows: felling July to August; skidding September to November; and loading and hauling October to December.

Both green and fire-killed lumber will be felled early in the summer months to permit natural drying before removal from the harvesting sites.

...ding will be undertaken using equipment similar to the small air-cooled Krabat machine (see Appendix FH-6). Logs will be bucked to 6-7 meters in length for winter sleigh hauling. Logs will be loaded and unloaded from the sleighs

FIGURE 9

PROJECTED WOOD BIOMASS REQUIREMENT FOR FORT HOPE
1984 - 2003

SCENARIO 1

YEAR	POPULATION	PERCENTAGE GROWTH	POWER CONSUMPTION (kwh)	PARASITIC LOAD (kwh)	TOTAL LOAD (kwh)	BIOMASS REQUIREMENT (tonnes)
1984	767	0.0	339,035	219,000	558,035	3,906
1988	851	9.9	372,599	219,000	591,599	4,141
1993	961	11.4	415,075	219,000	634,075	4,439
1998	1,085	11.4	462,394	219,000	681,394	4,770
2003	1,228	11.6	516,032	219,000	735,032	5,145

Note:

Parasitic Load* = 25 kw x 8760 hrs/yr = 219,000 kwh

Biomass Requirement: 7.0 kg/kwh for this generating system taking into consideration 70% boiler and 10% steam engine efficiencies. The biomass requirement is for the year shown.

SCENARIO 2

YEAR	POPULATION	PERCENTAGE GROWTH	POWER CONSUMPTION (kwh)	PARASITIC LOAD (kwh)	TOTAL LOAD (kwh)	BIOMASS REQUIREMENT (tonnes)
1984	767	0.0	1,078,000	438,000	1,516,000	10,612
1988	851	9.9	1,184,722	438,000	1,622,722	11,359
1993	961	11.4	1,319,780	438,000	1,757,780	12,304
1998	1,085	11.4	1,470,235	438,000	1,908,235	13,358
2003	1,228	11.6	1,640,782	438,000	2,078,782	14,551

Note:

Power Production of 1,078,000 (total proposed school, forest operations and community development) See Appendix FH-5 for details.

Parasitic Load* = 50 kw x 8760 hrs/yr = 438,000 kwh

Biomass Requirement: 7.0 kg/kwh for this generating system taking into consideration 70% boiler and 10% steam engine efficiencies. The biomass requirement is for the year shown.

One tonne of wood biomass is equivalent to approximately 0.7 cords of semi-dry wood.

*Note: Parasitic load is defined as the energy consumed within a boiler house and for auxiliary uses (lights, fans, etc.) which are required to support the energy system. Parasitic load does not increase significantly with power consumed.

using equipment similar to the Mor-bell logger (see Appendix FH-7).

All logs larger than 24 cm. in diameter will be used for fuelwood or lumber. The proposed electric biomass chipper can only accept logs up to 24 cm. in diameter. A chipper similar to that contained in Appendix FH-8 may be used.

Equipment similar to the Mor-bell logger, besides loading and unloading the hauling sleighs, will be used for sorting logs at the wood compound, feeding the chipper, placing sawlogs on the sawmill deck, and loading fuelwood for local delivery.

Special skills training will be required for the operation and maintenance of the proposed harvesting and processing machinery and equipment.

The total estimated capital cost of the harvesting, delivery and processing equipment is $275,600. Details of this cost estimate are contained in Appendix FH-9.

4.6 Economic and Social Considerations

i) Biomass Fuel

This section of the report contains: an estimate of the cost of biomass feedstock delivered to the generating system and projections of this cost.

Wood Biomass

The 1984 cost per green tonne for harvesting and delivery of biomass to the generating sytem is estimated to be $26.40. Appendix FH-10 contains details of the cost estimate.

Figure 10 contains projections of the wood biomass cost per tonne to the year 2003. This estimate is based on an annual cost increase of 5%.

FIGURE 10

PROJECTED WOOD BIOMASS COST

YEAR	WOOD BIOMASS COST/TONNE ($)
1984	26.40
1988	33.00
1993	41.25
1998	51.56
2003	64.45

ii) Fuel Oil

Fuel oil price forecasts contained in Figure 11 are based on scenario 2, which assumes that the proposed community expansion and forest harvesting operations are developed.

iii) Fuel Cost Comparison

The fuel cost comparison in Figure 12 is based on scenario 2.

FIGURE 11

PROJECTED FUEL OIL COST

YEAR	ESTIMATED POWER REQUIREMENT (kwh)	ESTIMATED FUEL OIL REQUIREMENT (l)	ESTIMATED PRICE OF FUEL OIL ($/l)	ESTIMATED FUEL OIL COST ($)
1984	1,078,000	481,250	0.63	303,187
1988	1,184,722	528,890	0.82	433,689
1993	1,319,780	589,180	1.09	642,206
1998	1,470,235	656,350	1.67	1,096,104
2003	1,640,782	732,490	2.34	1,714,026

Note:

Estimated Power Requirement: Scenario 2; power consumption + parasitic load

Estimated Fuel Oil Requirement: based on the production of 2.24 kwh per litre of fuel oil

Projected Fuel Oil Cost: based on 1984 price of fuel oil in Fort Hope of $0.63 per litre and Ontario Ministry of Energy Forecasts (Dec. '83).

FIGURE 12

WOOD BIOMASS AND FUEL OIL COST COMPARISON

A: ELECTRICAL GENERATION DIESEL FUEL DISPLACEMENT

YEAR	REQUIRED BIOMASS (tonnes)	BIOMASS COST/TONNE ($)	TOTAL BIOMASS COST ($)	TOTAL FUEL OIL COST ($)	NET FUEL SAVINGS ($)
1984	10,612	26.40	280,157	303,187	23,030
1988	11,359	33.00	374,847	433,689	58,842
1993	12,304	41.25	507,540	642,206	134,666
1998	13,358	51.56	688,738	1,096,104	407,366
2003	14,551	64.45	937,812	1,714,026	776,214

Notes: Required Biomass: based on "Scenario 2" power requirements

Biomass Cost/Tonne: increases in increments of 5% per annum

Fuel Oil Cost: based on 1984 price of fuel oil in Fort Hope of $.63 per litre, with annual increments based on Ont. Ministry of Energy Forecasts (Dec. 1983)

B: POTENTIAL HEATING FUEL DISPLACEMENT

(displaced by cogeneration)

YEAR	ESTIMATED FUEL OIL REQUIREMENTS (1)	ESTIMATED PRICE OF FUEL OIL ($/L)	ESTIMATED HEATING OIL COST ($)
1984	224,457	0.63	141,408
1988	224,457	0.82	184,054
1993	224,457	1.19	267,104
1998	224,457	1.67	374,843
2003	224,457	2.34	525,229

Notes:

Estimated Fuel Oil Requirements: based on 1983 consumption figures + an additional 60,000 l for future school & recreation complex
- assumes no additional oil fuelled facilities installed.

Estimated Fuel Oil Cost: based on 1984 price of fuel oil in Fort Hope of $.63 per litre and Ont. Ministry of Energy cost forecast (Dec. 1983)

FIGURE 12 (cont'd)

WOOD BIOMASS AND FUEL OIL COST COMPARISON

C: TOTAL ELECTRICAL GENERATION AND POTENTIAL HEATING OIL DISPLACEMENT

YEAR	REQUIRED BIOMASS (tonnes)	BIOMASS COST/TONNE ($)	TOTAL BIOMASS COST ($)	TOTAL* FUEL OIL COST ($)	NET FUEL SAVINGS ($)
1984	10,612	26.40	280,157	444,595	164,438
1988	11,359	33.00	374,847	617,743	242,896
1993	12,304	41.25	507,540	909,310	401,770
1998	13,358	51.56	688,738	1,470,947	782,209
2003	14,551	64.45	937,812	2,239,255	1,801,443

* Combined cost for Heating and Electrical Generation

Notes: Required Biomass: based on "Scenario 2" power requirements

Biomass Cost/Tonne: increases in increments of 5% per annum

Fuel Oil Cost: based on 1984 price of fuel oil in Fort Hope of $.63 per litre, with annual increments based on Ont. Ministry of Energy Forecasts (Dec. 1983)

iv) Generating Systems Capital Cost Estimates

a) Biomass Fuelled Cogeneration System

The total estimated cost to install a cogeneration biomass fuelled generating system, including equipment and infrastructure, is $2,230,000. Appendix FH-11 contains the details of this estimate.

The capital cost of the generating system plus capital cost of the harvesting, processing and transportation equipment results in a total estimated capital cost of $2,505,600.

b) Diesel Fuelled Generating System

Based on discussions with private contractors and personnel with Ontario Hydro, 1984 installation cost for a diesel generating system of the required 500 kw capacity is estimated to be $1,064,000.

v) Integrated Forest harvesting Operation

The wood biomass harvesting system is designed to incorporate the harvest of fuelwood and production of lumber. Figure 13 contains estimates of economic opportunities which are anticipated to result from development of the total forest harvesting operation.

FIGURE 13

ESTIMATED ECONOMIC BENEFITS OF FOREST HARVESTING OPERATION
(1984 Estimates)

1. Wood Biomass vs Diesel Electricity Net Benefit	$ 23,030
2. Wood Biomass vs Fuel Oil for Heating Net Benefit	$ 141,408
3. Fuelwood Production 850 x $60/cord	$ 51,000
4. Lumber Production 250,000 Fbm x $0.40/Fbm	$ 100,000
TOTAL ECONOMIC BENEFIT	$ 315,438

Note: Fbm - Foot board measure

Figure 14 contains projected estimates of economic benefits for forest harvesting opeations to the year 2003.

FIGURE 14

PROJECTED ECONOMIC BENEFITS OF FOREST HARVESTING OPERATION

	1984 ($)	1988 ($)	1993 ($)	1998 ($)	2003 ($)
1. Wood Biomass vs Diesel Generated Electricity Net Benefit	23,030	58,842	134,666	407,366	776,208
2. Wood Biomass vs Heating Fuel Oil Net Benefit	141,408	184,054	267,104	374,843	525,229
3. Fuelwood Production	51,000	61,644	75,504	93,404	114,624
4. Lumber Production	100,000	110,000	121,000	133,100	146,410
Totals	315,438	414,540	598,274	1,008,713	1,562,461

Notes:

1. Wood Biomass vs Electricity and Wood Biomass vs Heating - See Figure 12 A and B
2. Fuelwood Production and Value: based on $60/cord with a price increase of 2% per annum
3. Lumber Production Value: based on $400 per 1000 Fbm and an annual increase of 2% per annum (Fbm - Food board measure)

vi) Employment Created

Based on scenario 2, it is estimated that a total of 17 persons would be employed, primarliy on a seasonal basis, in the harvesting, processing and delivery of biomass and staffing of the energy plant in 1984. This would represent a total of approximately $265,000 in wages at

1984 salary levels. The boiler house positions require a substantial amount of training (i.e. stationary engineer) and cannot generally be filled immediately by local employables.

Details of the types and duration of employment created are contained in Appendix FH-12.

vii) Economic Analysis

The preliminary economic analysis, that was conducted by the Ontario Ministry of Energy, was based on the economic data obtained during this study. The revenue that would result from installation of a biomass fuelled generating system consisted of the fuel oil saving from electrical generation, and space heating (i.e. commercial and institutional buildings) and revenue from the integrated forest harvesting operation (i.e. lumber and fuelwood). The revenue did not include the estimated $265,000 annually in wages that may be created for the community members. The analysis revealed a rate of return of 0.33 per year and thus a payback period of three years. Details of this analysis are contained in Appendix FH-13.

4.7 Environmental Impact

The harvesting of biomass, fuelwood and sawlogs within the Fort Hope Indian Reserve will result in the improvement of forest stands. Harvesting will take place in fire-killed stands and old and dying poplar and birch stands, which can then be reforested.

The logging method will permit small area clear-cuts along an established winter road system. Planting will take place where natural regeneration is not sufficient.

Approval has been provided by the Fort Hope Indian Band for logging of fire-killed and decadent poplar and birch stands.

4.8 Administrative Framework

A biomass fuelled energy system should be owned and operated by the Fort Hope Power authority. Capital funding for harvesting, transportation and processing of wood biomass should be through the Fort Hope Indian Band and the Department of Indian Affairs and Northern Development (DIAND).

4.9 Conclusions

Sufficient sources of wood biomass are available from fire-killed and over-mature stands of timber to satisfy the requirements of the community on a sustained yield basis.

Wood biomass feedstock may be harvested, processed and delivered to the generating system at the relatively low cost of $26.40 per green tonne.

The system which is developed for the harvesting, processing and delivery of wood biomass feedstock should be an integrated forest harvesting operation that would also include the production of lumber and fuelwood.

The optimum biomass fuelled cogeneration system would consist of two-250 kw fire tube boiler/steam engines.

The preliminary economic analysis, conducted by the Ontario Ministry of Energy, reveals that the payback period for a biomass fuelled cogeneration system installed in Fort Hope would be 3 years.

There was potential for employment of 17 persons in 1984.

These persons would be employed in the integrated forest harvesting operation and staffing of the energy plant. This would represent approximately $265,000 in wages.

If a biomass fuelled cogeneration system is installed in Fort Hope it should be owned and maintained by the Fort Hope Power Authority. The optimum method for supply of wood biomass feedstock would be for the Band to form a forest harvesting company to supply feedstock on contract to the operator of the system.

CHAPTER 5

WEAGAMOW (ROUND LAKE)

5.1 Opportunities and Constraints of a Biomass Fuelled Generating System

Opportunities

A fuelwood delivery system has been developed by the Band and potential exists for development of wood biomass harvesting and lumber production based on expansion of the existing fuelwood system.

Installation of a biomass fuelled generation system may result in the creation of 19 jobs, resulting in approximately $302,360 in wages for the community members.

Excellent winter road access is available for generating system equipment.

Band leadership and administration are strong and well organized.

The community members are interested in biomass energy technology.

More than sufficient forest resources are available to satisfy the estimated biomass requirements.

Constraints

The estimated cost of wood biomass is high relative to the other study communities.

There is limited potential for cogeneration.

An agency was not identified that would provide the capital and operating funds for a biomass fuelled generating system.

5.2 Optimum Biomass Fuelled Generating System

It is estimated that this community will require a total of approximately 300 kw of power. The optimum system to satisfy this demand should consist of two-150 kw fire tube boiler/steam engines. One steam engine would provide the required base load and the second would be used for standby, parasitic load and production of biomass. (See section 5.4 for details of capacity required.)

The proposed boiler/steam engine system should be located adjacent to the existing diesel units in the vicinity of the airport. The existing diesel units would be maintained for standby use.

A schematic diagram of the recommended generation system is contained in Appendix W-1.

Appendices FH-2 and 3 contain specifications for typical boilers and steam engines.

5.3 Source of Biomass

Wood Biomass

Three areas are available for the harvest of biomass within economical haulage distance of the community. Area 1 consists of the Reserve; Area 2 is located east of the Reserve in the vicinity of the existing sawmill; and Area 3 is located on the southeast side of Weagamow Lake. Access to Area 3 will be available via the winter road to Pickle Lake.

Figure 15 contains a summary of the volumes of biomass available from each of the three potential biomass harvesting areas.

FIGURE 15

SOURCE OF BIOMASS

AREA	AREA (hectares)	GROSS VOLUME (cunits) 7"	GROSS VOLUME (cunits) 8"+	GROSS CORDS	TOTAL BIOMASS AVAILABLE (tonnes)
AREA #1					
Reserve	911.6	12,140	4,271	26,258	53,527
AREA #2					
Summer Logging Area Crown Land	1,602.1	20,956	15,923	59,007	120,286
AREA #3					
Winter Logging Area Crown Land	1,979.1	20,429	25,869	74,077	151,006
TOTAL	4,492.8	53,525	46,063	159,342	324,818

Notes:

Calculations

Gross Cords = Cunits total per stand no. x 1.28 (cunits to cords)
x 1.25 (25% extra biomass)

Total Biomass tonnes = Gross Cords x 4500 (1 cord = 4500 lbs)
x .453 (.453 kg in a lb)
x .001 (1000 kg in a tonne)

one cord = approximately 2 tonnes of green wood.

The locations of the potential harvesting areas are shown on Map W-4, Appendix W-4.

Approximately 5,000 tonnes (2,500 cords) of wood biomass will be required per year. More than sufficient volumes are available on the east side of the Reserve and adjacent Crown Land.

Peat

Preliminary investigations indicated that the potential is poor for use of peat as a source of biomass fuel for this community. Therefore, detailed investigations were not conducted.

5.4 Biomass Requirement

Based on an existing power requirement of approximately 700,000 kwh per year, it was estimated that approximately 5,000 tonnes (2,500 cords) of wood biomass would be required to satisfy the annual power requirement of the community. There is no major community expansion planned. The projections of biomass requirements contained in Figure 16 are based on normal community growth.

5.5 Biomass Harvesting Transportation and Processing Methods

Production of wood biomass should be totally integrated with production of lumber and fuelwood.

It is recommended that an overland winter haul road be constructed from the airport to the present site of the sawmill on Agutua Arm. Also a connecting winter haul road should be constructed to Keeyask Lake.

The present portable sawmill should be permanently located in the vicinity of the airport in conjunction with the energy system.

Harvesting of timber to produce wood biomass would take place in Areas 1 and 2 during a five month period (August to December). Harvesting and hauling in Area 3 would be conducted during the winter.

Harvesting would be undertaken using the small area clear cut method (50-100 ha). Fire-killed timber would be used as

FIGURE 16

PROJECTED WOOD BIOMASS REQUIREMENTS

YEAR	POPULATION	PERCENTAGE GROWTH	POWER CONSUMPTION (kwh)	PARASITIC LOAD (kwh)	TOTAL LOAD (kwh)	BIOMASS REQUIREMENT (tonnes)
1984	543	0.0	491,550	219,000	710,550	4,974
1988	601	9.8	539,722	219,000	758,722	5,311
1993	671	10.4	595,853	219,000	814,853	5,704
1998	740	9.3	651,267	219,000	870,267	6,092
2003	807	8.3	705,322	219,000	924,322	6,470

Note:

Power Consumption: previous year + percentage of previous year

Parasitic Load:* 25 kw x 8700 hrs in a year = 219,000 kwh

Total Load: Parasitic + Power Consumption

Biomass Requirement: 7.0 kg/kwh for this generating system taking into consideration 70% boiler and 10% steam engine efficiencies. The biomass requirement is for the year shown.

One tonne of wood biomass is equivalent to approximately 0.5 cords of green wood.

*Note: Parasitic load is defined as the energy consumed within a boiler house and for auxiliary uses (lights, fans, etc.) which are required to support the energy system.

available where haul distances are economical. Logs will be bucked to 6-7 meters in length for hauling to the wood compound.

Wood chips would be produced with an electrically driven chipper at the energy plant and blown directly into the biomass storage bunker.

The total estimated capital cost of the harvesting, delivery and processing equipment is $243,500. Details of this cost estimate are contained in Appendix W-3.

5.6 Economic and Social Considerations

i) Biomass Fuel

This section of the report contains an estimate of the cost of biomass feedstock delivered to the generating system and projections of this cost.

Wood Biomass

The 1984 estimated cost per green tonne for harvesting and delivery of biomass to the generating system is $33.66. This cost includes depreciation and labour. Appendix W-4 contains details of this estimate.

Figure 17 contains projections of the cost per tonne for wood biomass to the year 2003. This estimate is based on an annual cost increase of 5%.

FIGURE 17

PROJECTED WOOD BIOMASS COST

YEAR	WOOD BIOMASS COST/TONNE
1984	$33.66
1988	$42.08
1993	$52.60
1998	$65.75
2003	$82.19

ii) Fuel Oil

Figure 18 contains a fuel oil price forecast based on a 1984 fuel oil price of $0.39 per litre in Weagamow.

FIGURE 18

PROJECTED FUEL OIL COST

YEAR	ESTIMATED POWER REQUIREMENT (kwh)	ESTIMATED FUEL OIL REQUIREMENT (l)	ESTIMATED PRICE PER LITRE OF FUEL OIL ($)	ESTIMATED FUEL OIL COST ($)
1984	491,550	223,431	0.39	871,138
1988	539,722	245,328	0.49	120,210
1993	595,853	270,841	0.72	195,005
1998	651,267	296,030	1.01	298,990
2003	705,322	320,600	1.41	452,046

Note:

Estimated Power Requirement: Power consumption + Parasitic load (25 kw)

Estimated Fuel Oil Requirement: based on the consumption of 2.2 litres of fuel to produce a kwh

Estimated Fuel Oil Cost: Ministry of Energy Price Projections (Dec. 1983)

iii) Fuel Cost Comparison

Figure 19 provides a comparison of the projected costs of wood biomass and fuel oil.

FIGURE 19

WOOD BIOMASS AND FUEL OIL COST COMPARISON

YEAR	REQUIRED BIOMASS (tonnes)	BIOMASS COST/TONNE ($)	TOTAL BIOMASS COST ($)	TOTAL FUEL OIL COST ($)	NET FUEL SAVINGS ($)
1984	4,974	33.66	167,425	87,138	(80,287)
1988	5,311	42.08	223,487	120,210	(103,277)
1993	5,704	52.60	300,030	195,005	(105,025)
1998	6,092	65.75	400,549	298,990	(101,559)
2003	6,470	82.19	531,769	452,046	(79,723)

Notes:

Estimated Biomass: growth based on population growth figures

Estimated Biomass Cost/Tonne: increase of 5% per annum

Estimated Fuel Oil Cost: based on Ont. Ministry of Energy Projection (Dec. 1983)

iv) Generating Systems Capital Cost Estimates

a) Biomass Fuelled Generating System

The total estimated cost to install a biomass fuelled generating system is $1,140,000. Appendix W-4 contains details of this estimate.

The capital cost of the generating system plus capital cost of harvesting and delivery system results in a total estimated capital cost of $1,383,500 to install the complete harvesting, delivery and generation system.

b) Diesel Fuelled Generating System

Based on discussions with private cosntractors and personnel with Ontario Hydro the 1984 installation cost for a diesel generating system of the required 300 kw capacity is estimated to be $798,000.

v) Employment Created

It is estimated that 19 persons would be employed, primarily on a seasonal basis, in forest harvesting and processing operations and staffing of the energy plant in 1984. This would result in a total of approximately $302,360 in wages at 1984 levels. Details of the types and duration of employment created are contained in Appendix W-5.

The boiler house positions require a substantial amount of training (i.e. stationary engineer) and cannot generally be filled immediately by local employables.

vi) Economic Analysis

The economic analysis conducted by the Ontario Ministry of Energy indicates a rate of return of -1.85 per year and reveals that payback on a biomass fuelled generating sytem would not occur within the 20 year projection period of this study. This analysis was based on economic data acquired during this study and the wages that may be created for the community members were not included as revenue from the system. Details of this analysis are contained in Appendix W-6.

5.7 Environmental Impact

Production of wood biomass would be based upon the harvesting of softwood stands on the Reserve and immediately adjacent Crown Land.

Logging would be based upon small area clear-cuts adjacent to an established winter road network. Natural regeneration is expected to be sufficient. Cut-overs showing lack of sufficient natural regeneration would be reforested.

5.8 Administration Framework

A biomass harvesting, transportation and processing system in Weagmow should be owned and operated by the Band. Wood biomass should be supplied under contract to Ontario Hydro, the proposed operator of the energy system.

5.9 Conclusions

Sufficient sources of wood biomass are available within economical haul distances of the community to satisfy the requirements of the community on a sustained yeild basis.

The cost for harvesting, processing and delivery of wood biomass feedstock in 1984 is estimated to be $33.66 per green tonne. This cost is high relative to the other study communities. The optimum biomass generating system for this community is two 150 kw fire tube boiler/steam engines.

The preliminary economic analysis, conducted by the Ontario Ministry of Energy, reveals that payback on a biomass fuelled generating system would not likely occur within the 20 year projection period of this study.

There was potential in 1984 for employment of 19 persons in biomass supply and energy system operation. This employment would create approximately $302,360 in wages annually.

The biomass supply system should consist of an integrated forest harvesting operation which would include the harvest, processing and delivery of wood biomass feedstock, fuelwood and lumber.

Should a biomass fuelled generating system be installed in Weagamow it is recommended that it be maintained under the present mandate of Ontario Hydro. The biomass harvesting,

delivery and processing system should be owned and operated by the Band and feedstock supplied under contract to the system operator.

CHAPTER 6

GULL BAY

6.1 Opportunities and Constraints of a Biomass Fuelled Generating System

The following is a brief description of major opportunities and constraints to economical operation of a biomass fuelled generating system in Gull Bay.

Opportunities

A sufficient supply of wood biomass is available from existing forest harvesting operations of the Gull Bay Indian Band, Great Lakes Forest Products, Abitibi Forest Products, and Domtar Inc.

Installation of a biomass fuelled generating system may result in the creation of 11 jobs, resulting in approximately $233,000 in wages for the community members.

This community is stable and has strong, well organized leadership and Band administration.

The Band is currently involved in forest harvesting operations.

Excellent all weather roads are available for delivery of the generating system equipment and wood biomass.

Potential exists for economic development, which could include cogeneration for heating of greenhouses.

Constraints

The cost of wood biomass is high relative to other study communities.

The community members have limited interest in wood biomass energy technology for supply of the community's energy requirements, due to a diesel generating and power distribution system recently being installed by Ontario Hydro.

Potential is limited for cogeneration.

The potential economic benefits are only moderate relative to other study communities.

An agency was not identified that would provide the capital and operating funds for a biomass fuelled generating system.

6.2 Optimum Biomass Fuelled Generating System

A fire tube boiler/steam engine capable of producing 200 kw would be the optimum biomass fuelled generating system for this community. (See section 6.4 for details of the capacity required.)

It is assumed that the existing diesel units would be maintained and used for standby.

A schematic diagram of the recommended wood biomass energy system is contained in Appendix G-1. Appendices FH-2 and 3 contain specifications for typical boilers and steam engines

6.3 Source of Biomass

Wood Biomass

The production of wood biomass will be based upon the salvage of logging residues and residual trees from cut over areas of the Kiashke River Native Development Inc., Forestry Contractors. This group has long-term commitments to produce 25,000 to 39,000 tonnes (12,500 to 19,500 cords) of

pulpwood and sawlogs per year from its timber limit (Timber Licence No. 363200) and from adjoining timber licences of Domtar, Great Lakes and Abitibi. This is expected to yield between 6,000 and 10,000 tonnes (3,000 and 5,000 cords) of residues annually. This is in excess of the approximately 5,000 tonnes (2,500 cords) of biomass required annually to satisfy the power requirements of the community.

Peat

Preliminary investigations indicated that the potential was only moderate for use of peat as a source of biomass fuel for this community. Therefore, detailed investigations were not conducted.

6.4 Biomass Requirements

It is estimated that approximately 5,350 tonnes (2,675 cords) of wood biomass will be required to produce the estimated 750,000 kwh of power necessary to satisfy the demand of the community. Community representatives expressed strong interest in the development of commercial tree nursery greenhouses, therefore, the estimated power requirement is based on the existing community requirements plus an additional 50 kw for economic development.

Figure 20 contains estimates of future power and biomass requirements, under two different scenarios. Scenario 1 is based on normal growth of the community, and scenario 2 is based on normal community growth plus development of commercial greenhouses.

6.5 Biomass Harvesting, Transportation and Processing Methods

A mobile field chipper will be employed that will directly follow the logging crew. Slash and residual trees will be hauled directly to the chipper. Chips will be blown into

FIGURE 20

PROJECTED WOOD BIOMASS REQUIREMENT

YEAR	POPULATION	PERCENTAGE GROWTH	POWER CONSUMPTION (kwh)	PARASITIC LOAD (kwh)	TOTAL LOAD (kwh)	BIOMASS REQUIRMENT (tonnes)
1984	370	0.0	326,216	219,000	545,216	3,817
1988	409	9.5	357,206	219,000	576,206	4,033
1993	448	8.7	379,709	219,000	598,709	4,191
1998	478	6.3	403,631	219,000	622,631	4,358
2003	509	6.1	438,252	219,000	657,252	4,601

Notes:

Parasitic Load:* 25 kw x 8760 hrs/yr = 219,000 kwh

Biomass Requirement: 7.0 kg/kwh for this generating system taking into consideration 70% boiler and 10% steam engine efficiencies. The biomass requirement is for the year shown.

SCENARIO 2

YEAR	POPULATION	PERCENTAGE GROWTH	POWER CONSUMPTION (kwh)	PARASITIC LOAD (kwh)	TOTAL LOAD (kwh)	BIOMASS REQUIRMENT (tonnes)
1984	370	0.0	326,216	438,000	764,216	5,350
1988	409	9.5	357,206	438,000	795,206	5,566
1993	448	8.7	379,709	438,000	817,709	5,724
1998	478	6.3	403,631	438,000	841,631	5,891
2003	509	6.1	438,252	438,000	876,252	6,134

Notes:

Parasitic Load:* 50 kw parasitic load + 50 kw for economic development = 100 kw at 50% load factor = 438,000 kwh/yr

Biomass Requirement: 7 kg/kwh for this generating system taking into consideration 70% boiler and 10% steam engine efficiencies. The biomass requirement is for the year shown.

*Note: Parasitic load is defined as the energy consumed within a boiler house and for auxiliary uses (lights, fans, etc.) whic are required to support the energy system.

large capacity dump trucks for delivery to the energy system bunker.

The total estimated capital cost of the biomass harvesting, delivery and processing equipment is $156,000. Details of this cost estimate are contained in Appendix G-2.

6.6 Economic and Social Considerations

i) Biomass Fuel

This section of the report contains: an estimate of the cost of biomass feedstock delivered to the generating system and projections of this cost, a projection of the fuel oil cost, a comparison of the biomass and fuel oil projections and estimates of the net fuel saving that may result from use of biomass fuel.

Wood Biomass

The 1984 cost per green tonne for harvesting and delivery of biomass to the generating system is estimated to be $34.50. This cost includes depreciation and labour. Appendix G-3 contains details of this cost estimate.

Figure 21 contains a projection of wood biomass cost per tonne to the year 2003. This projection is based on a 5% annual increase.

ii) Fuel Oil

The fuel oil price forecasts contained in Figure 22 are based on scenario 2, which assumes normal community growth plus development of a commercial greenhouse.

FIGURE 21

PROJECTED WOOD BIOMASS COST

YEAR	WOOD BIOMASS COST/TONNE ($)
1984	34.50
1988	43.13
1993	53.91
1998	67.39
2003	76.68

FIGURE 22

PROJECTED FUEL OIL COST

YEAR	ESTIMATED POWER REQUIREMENT (kwh)	ESTIMATED FUEL OIL REQUIREMENT (l)	ESTIMATED PRICE OF FUEL OIL ($/l)	ESTIMATED FUEL OIL COST ($)
1984	544,216	247,370	0.35	86,580
1988	576,206	261,911	0.46	120,479
1993	598,700	272,136	0.67	182,331
1998	622,631	283,014	0.94	266,033
2003	657,252	298,750	1.32	394,350

Note:

Estimated Fuel Oil Requirement: based on consumption of 2.2 kw

Estimated Fuel Oil Cost: based on 1984 price of fuel oil in Gull Bay of $.35 per litre and Ont. Ministry of Energy Fuel Oil Price Forecasts (Dec. '83)

Economic development load consists of 50kw at a 50% load factor.

iii) Fuel Cost Comparison

The fuel cost comparison contained in Figure 23 is based on scenario 2.

FIGURE 23

WOOD BIOMASS AND FUEL OIL COST COMPARISON

YEAR	REQUIRED BIOMASS (tonnes)	BIOMASS COST/TONNE ($)	TOTAL BIOMASS COST ($)	TOTAL FUEL OIL COST ($)	NET FUEL SAVINGS ($)
1984	5,350	34.50	184,575	86,580	(97,995)
1988	5,566	43.13	240,062	120,479	(119,583)
1993	5,724	53.91	308,581	182,331	(126,250)
1998	5,891	67.39	396,994	266,033	(130,961)
2003	6,134	76.68	470,355	394,350	(76,005)

Notes:

Estimated Biomass Requirement: based on Scenario 2 Forecasts

Fstimated Biomass Cost/Tonne: increases at 5% per annum

Estimated Fuel Oil Costs: based on a price of $.35/l and Ontario Ministry of Energy Forecasts (Dec./83)

iv) Generating Systems Capital Cost Estimates

a) Biomass Fuelled Generating System

The estimated capital cost to install the biomass generating system is $820,000. Appendix G-2 contains details of this estimate.

The estimated capital cost of $156,000 for the biomass harvesting and delivery system plus the above estimate for the generating system results in a total estimated capital cost of $976,000 for the entire biomass energy system.

b) Diesel Fuelled Generating System

Based on discussion with private contractors and personnel with Ontario Hydro the 1984 installation cost for a diesel generating system of the required capacity is estimated to be $585,000.

v) Employment Created

Wood Biomass

Based on scenario 2, it is estimated that, in 1984, a total of 11 persons would be employed, primarily on a full time basis, in the harvesting and delivery of biomass and staffing of the energy plant. This represents a total of approximately $233,000 in wages. Details of the types and duration of employment created are contained in Appendix G-4.

The boiler house positions require a substantial amount of training (i.e. stationary engineer) and cannot generally be filled immediatly by local employables.

vi) Economic Analysis

The economic analysis conducted by the Ontario Ministry of Energy indicates a rate of return of -1.84 per year and reveals that payback on a biomass fuelled generating system would not occur within the 20 year projection period of this study. This analysis was based on economic data acquired during this study and the wages that may be created for the community members were not included as revenue from the system. Details of this analysis are contained in Appendix W-5.

6.7 Environmental Impacts

The removal of logging slash and residual trees will be of assistance to the Kiashke River Native Development Inc.,

Forestry Contractors, in their present responsibilites for scarification and reforestation.

There will be no significant environmental impacts associated with the harvesting of wood biomass.

6.8 Administrative Framework

The harvesting, transportation and processing of wood biomass should be undertaken by Kiashke River Native Development Inc., a wholly owned forestry contracting company of the Gull Bay Indian Band. Wood biomass would be generated during normal logging operations which are presently undertaken by the Band.

Ontario Hydro has the jurisdiction and responsibility for production and distribution of electrical power in Gull Bay.

6.9 Conclusions

Sufficient amounts of wood biomass are available to satisfy the requirements of the community on a sustained yield basis. The biomass feedstock could be produced from salvage of logging residues and residual trees from cut over areas of the Kiaske River Native Development Inc., a Band owned forest harvesting contracting company. The cost per green tonne for wood biomass delivered to the generating system is estimated to be $34.50. This cost is relatively high.

The optimum biomass fuelled generating system would be a 200 kw fire tube boiler/steam engine.

The preliminary economic analysis, conducted by the Ontario Ministry of Energy, reveals that payback on a biomass fuelled generating system would not likely occur within the 20 year projection period of this study.

There was potential for employment of 11 persons, representing approximately $233,000 annually in wages, in the harvesting and processing of wood biomass and staffing of the energy plant in 1984.

Should a biomass fuelled generating sytem be installed it is recommended that it be maintained under the present mandate of Ontario Hydro. The biomass harvesting, delivery and processing system should be owned and operated by the Kiaske River Native Development Inc. and feedstock supplied under contract to the system operator.

CHAPTER 7

SUMMARY OF RESULTS

7.1 Reconnaissance Level Study Communities

An evaluation of the 44* remote communities in northern Ontario resulted in the identification of six communities having the highest potentials for economically viable operation of biomass fuelled generating systems. These six communities are, in order of descending potential: Armstrong; Gull Bay; Fort Hope; Bearskin Lake; Weagamow (Round Lake); and Collins. The locations of these communities are shown in Figure 1.

7.2 Detailed Study Communities

From the six communities recommended for reconnaissance level study, the four communities having the highest potentials for economically viable operation of biomass fuelled generating systems were identified. The following four communities, listed in order of descending potential, exhibited the highest potentials and were therefore investigated in detail: Armstrong, Fort Hope, Weagamow (Round Lake), and Gull Bay.

7.3 Opportunities and Constraints

Figure 24 contains summaries of the major opportunities and constraints to economical operation of a biomass fuelled generating system in each of the detailed study communities.

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* Note: Under Energy, Mines and Resources Canada's Remote Community Demonstration Program 41 communities are considered remote.

FIGURE 24

SUMMARY OF OPPORTUNITIES AND CONSTRAINTS

COMMUNITY	OPPORTUNITIES	CONSTRAINTS
Armstrong	-suitable for either boiler/ steam turbine or gasifier/ dual fuel engine. -relatively low cost biomass. -wood fibre and peat available as possible fuel sources. -immediate demand for additional power. -may create 11 jobs and generate $264,000 annually in wages.	-lack of local government organization to coordinate construction and operation of a biomass fuelled generating system. -the capital and operating costs of biomass system are higher than diesel system. -cost of wood biomass fuel higher than diesel fuel until approx. the year 2003. -source of capital and operating funds was not identified.
Fort Hope	-community presently operates diesel generating and electrical distribution system. -large scale community expansion proposed. -potential exists for cogeneration. -potential exists for development of an integrated wood biomass, fuelwood and sawlog harvesting operation. -cost of wood biomass fuel presently less than diesel fuel. -may create 19 jobs and generate $227,600 in wages annually.	-only access for generating system equipment is winter cat track which can be used when demand and conditions warrant. -the capital and operating costs of biomass system higher than diesel system. -source of capital and operating funds was not identified.

FIGURE 24 - CONTINUED

COMMUNITY	OPPORTUNITIES	CONSTRAINTS
Weagamow (Round Lake)	-community fuelwood supply system presently exists, may be expanded to include biomass and sawlog harvest. -excellent winter road access for generating system equipment. -may result in the creation of 19 jobs resulting in in $302,360 in wages annually	-relatively high cost of wood biomass. -capital and operating costs of biomass system higher than diesel system. -source of capital and operating funds was not identified. -cost of biomass fuel is higher than diesel fuel until beyond the year 2003.
Gull Bay	-Band currently involved in forest harvesting. -excellent all weather road access. -may result in the creation of 11 jobs resulting in $233,000 in wages annually.	-cost of wood biomass relatively high. -potential economic benefits moderate relative to other study communities -capital cost of biomass system higher than diesel system. -cost of biomass fuel higher than diesel fuel until beyond the year 2003. -source of capital and operating funds was not identified.

7.4 Optimum Biomass Fuelled Generating Systems

Figure 25 contains the estimated electrical generating capacity which will be required to the year 2003, and a description of the optimum biomass fuelled generating system for each of the study communities.

FIGURE 25

OPTIMUM BIOMASS FUELLED GENERATING SYSTEMS

COMMUNITY	ELECTRICAL GENERATING CAPACITY (kw)	OPTIMUM SYSTEM
Armstrong	1,000	2-500 kw water tube boiler/steam turbines. A gasifier/dual fuel engine could be installed when successful demonstration of the technology has been completed and if this is determined to be an economically competative generating system, for this community.
Fort Hope	500	2-250 kw fire tube boiler/steam engines.
Weagamow (Round Lake)	300	2-150 kw fire tube boiler/steam engines.
Gull Bay	200	1-200 kw fire tube boiler/steam engine.

7.5 Sources of Biomass

The types and sources of biomass which are available to each community are listed in figure 26.

The supply of wood biomass to Armstrong, Fort Hope, Weagamow and Gull Bay is technically viable using available forest harvesting technology.

Armstrong is the only study community for which the supply of peat as a source of biomass fuel was investigated. The supply of fuel peat from the peatland north of the airport, which is the optimum peatland in the area, does not appear to be feasible using available dry mining techniques. Harvesting of this fuel peat may be practical when wet mining techniques have been developed for Canadian application.

FIGURE 26

SOURCES OF BIOMASS

COMMUNITY	TYPE OF BIOMASS	LOCATION
Armstrong	wood	- salvage of residues and residual unmerchantable tree species from existing logging operations in the Armstrong area (i.e. Armstrong Crown, Domtar Inc. and Great Lakes Forest products Mangement Units).
	peat	- peatland located north of Armstrong airport, contains sufficient quality and quantity of fuel grade peat to satisfy energy requirements of community for approximately 22 years. - harvesting of this peat is not practical using existing dry mining technology.
Fort Hope	wood	- more than sufficient volume available in fire-killed and over mature birch and poplar stands within the Reserve.
Weagamow (Round Lake)	wood	- more than sufficient volumes identified in three harvesting areas, within the Reserve, Crown Land east of Reserve, Crown Land southeast of Weagamow (Round Lake).
Gull Bay	wood	- salvage of residues and residual unmerchantable tree species, from existing logging operations of the Kiashke River Native Development Corp. (Band owned, timber licence No. 363200) and adjoining timber licences of Domtar Inc. Great Lakes Forest Products and Abitibi Price Forest Products.

7.6 Biomass Requirements

The biomass requirements for the communities which exhibit potential for significant community expansion or economic development were estimated based on two scenarios. Scenario 1 assumes normal growth of the community and scenario 2 assumes full development of the potential community expansion and/or economic opportunities. This provides a range of anticipated biomass requirements. The two

scenarios were calculated for Armstrong, Fort Hope and Gull Bay. The requirements for Weagamow (Round Lake) were based on normal growth of the community.

Figure 27 contains the anticipated biomass requirements for each community to the year 2003. This time period represents the 20 year anticipated life of the generating systems.

The biomass requirements are for the year indicated.

FIGURE 27

ESTIMATED WOOD BIOMASS REQUIREMENTS

COMMUNITY	1984 (TONNES)	1988 (TONNES)	1993 (TONNES)	1998 (TONNES)	2003 (TONNES)
Armstrong					
Scenario 1	10,854	11,503	12,375	13,320	14,354
Scenario 2	20,405	21,405	23,027	24,663	26,444
Gull Bay					
Scenario 1	3,817	4,033	4,191	4,358	4,601
Scenario 2	5,350	5,566	5,724	5,891	6,134
Fort Hope					
Scenario 1	3,906	4,141	4,439	4,770	5,145
Scenario 2	10,612	11,359	12,304	13,358	14,551
Weagamow					
Scenario 1	4,974	5,311	5,704	6,092	6,470

7.7 Biomass Harvesting, Transporting and Processing Methods

Figure 28 contains a summary of the biomass harvesting, transporting and processing techniques which are most appropriate for each community.

FIGURE 28

APPROPRIATE WOOD BIOMASS HARVESTING, TRANSPORTING AND PROCESSING METHODS

COMMUNITY	HARVESTING	TRANSPORTING	PROCESSING
Armstrong	-year round salvage of residues and residual unmerchantable tree species from existing forest operations at the stump and road sides.	-dump truck from field chipping site to bunkers at generating site.	-primarily field chipping -portable chipper at bunker and roadside to permit small scale logging operators to produce chips.
Fort Hope	-biomass production integrated with fuelwood and sawlog harvest -fire-killed and over mature poplar and birch stands. -felling in summer to permit natural drying. -logs bucked to 6-7m length.	-winter sleigh hauling of logs in 6-7m lengths.	-logs greater than 24 cm diameter used for fuelwood or sawlogs. -electric chipper at generating site
Weagamow	-biomass production integrated with fuelwood and sawlog production. -harvesting from August to December. -small area (50-100 ha) clear cut method. -logs bucked to 6-7m length.	-winter sleigh haul of logs to wood compound at generating site.	-logs greater than 24 cm diameter used for fuelwood or sawlogs -electric chipper at generating site

FIGURE 28 - CONTINUED

COMMUNITY	HARVESTING	TRANSPORTING	PROCESSIN
Gull Bay	-year round salvage of residues and residual unmerchantable tree species from existing logging operations.	-dump truck from field chipping site to bunker at generating site.	-mobile field chipper follows logging crew.

7.8 Economic and Social Considerations

i) Wood Biomass Fuel

Figure 29 contains the estimated cost of wood biomass fuel delivered to the generating system in each of study communities projected over the anticipated 20 year life of the generating systems.

FIGURE 29

BIOMASS FUEL COST ESTIMATES

	ARMSTRONG	FORT HOPE	WEAGAMOW	GULL BAY
YEAR	COST/GREEN TONNE ($)	COST/GREEN TONNE ($)	COST/GREEN TONNE ($)	COST/GREEN TONNE ($)
1984	23.23	26.40	33.66	34.50
1988	29.04	33.00	42.08	43.13
1993	36.30	41.25	52.60	53.91
1998	45.38	51.56	65.75	67.39
2003	56.73	64.45	82.19	76.68

Note:

Projecions are based on an annual increase of 5%.
Costs are for the year indicated.

ii) Biomass and Fuel Oil Cost Comparison

A comparison of the fuel oil and biomass fuel costs and estimation of the net saving, or loss (), which may result from the use of biomass fuel in each community are contained in Figure 30.

iii) Biomass Supply and Generating Systems Capital Cost Estimates

Figure 31 contains capital cost estimates for the biomass harvesting, processing and delivery and generating systems. These costs include items such as equipment, infrastructure, mobilization and interest during construction.

FIGURE 30

BIOMASS AND FUEL OIL COST COMPARISON

YEAR	FUEL OIL PRICE ($/l)	TOTAL FUEL OIL COST ($)	BIOMASS COST/TONNE ($/tonne)	TOTAL BIOMASS COST ($)	NET FUEL SAVINGS ($)
ARMSTRONG					
Wood Biomass					
1984	0.30	297,399	23.23	474,008	(176,609)
1988	0.39	414,047	29.04	625,056	(211,009)
1993	0.58	670,601	36.30	835,880	(165,279)
1998	0.82	1,032,470	45.38	1,119,206	(86,736)
2003	1.15	1,576,845	56.73	1,500,168	76,677
FORT HOPE					
Wood Biomass					
1984	0.63	303,187	26.40	280,157	23,030
1988	0.82	433,689	33.00	374,847	58,842
1993	1.19	642,206	41.25	507,540	134,666
1998	1.67	1,096,104	51.56	688,738	407,366
2003	2.34	1,714,026	64.45	937,812	776,214
WEAGAMOW					
Wood Biomass					
1984	0.39	87,138	33.66	167,425	(80,287)
1988	0.49	120,210	42.08	223,487	(103,277)
1993	0.72	195,005	52.60	300,030	(105,025)
1998	1.01	298,996	65.75	400,549	(101,559)
2003	1.41	452,046	82.19	531,769	(79,723)
GULL BAY					
Wood Biomass					
1984	0.35	86,580	34.50	184,575	(97,995)
1988	0.46	120,479	43.13	240,062	(119,583)
1993	0.67	182,331	53.91	308,581	(126,250)
1998	0.94	266,033	67.39	396,994	(130,961)
2003	1.32	394,350	76.68	470,355	(76,005)

Notes:

Estimates of fuel requirements are based on full development of potential community expansion and economic opportunies.

Biomass cost projections based on annual increase of 5%.

Fuel oil cost projections based on 1984 cost of fuel oil in each community and Ontario Ministry of Energy Forecasts (Dec.'83).

FIGURE 31

BIOMASS SUPPLY AND GENERATING SYSTEMS CAPITAL COST ESTIMATES

COMMUNITY	HARVESTING PROCESSING & TRANSPORTATION SYSTEM ($)	GENERATING SYSTEM ($)	TOTAL BIOMASS ENERGY SYSTEM ($)
ARMSTRONG	550,000	4,350,000	4,900,000
FORT HOPE	275,600	2,230,000	2,505,600
WEAGAMOW	243,500	1,140,000	1,383,500
GULL BAY	156,000	820,000	976,000

iv) Generating Systems Capital Cost Comparison

The required electrical generating capacity, the estimated cost per kw, and the total installation cost for the optimum biomass fuelled and equivalent capacity diesel generating system for each community are contained in Figure 32.

v) Generating Systems Operating and Maintenance Cost Estimates

The 1984 cost to operate and maintain the optimum biomass fuelled and comparable capacity diesel generating systems in each of the study communities were estimated. These estimates appear in Figure 33.

FIGURE 32

GENERATING SYSTEMS CAPITAL COST COMPARISON

COMMUNITY	ELECTRICAL CAPACITY (kw)	*OPTIMUM BIOMASS SYSTEM TYPE	COST/ KW ($)	TOTAL ($000)	DIESEL COST/ KW ($)	DIESEL TOTAL ($)	ADD. COST OF BIOMASS SYSTEM PER KW ($)	ADD. COST OF BIOMASS SYSTEM TOTAL ($000)
Armstrong	1,000	Steam Turbine	4,905	4,095	1,729	1,729	3,176	3,176
Fort Hope**	500	Steam Engine	3,851	1,926	2,128	1,060	1,723	866
Weagamow	300	Steam Engine	4,610	1,384	2,660	798	1,950	586
Gull Bay	200	Steam Engine	4,880	976	2,925	585	1,955	391

* Cost estimates for the biomass systems include the costs of the powe plant and generating system plus the costs of biomass harvesting, processing and transportation equipment or infrastructure which must be acquired to permit use of biomass as a fuel source.

**The biomass system cost is for the electrical generation system and excludes the cogeneration system. This permits comparison between the costs of the biomass and diesel systems.

FIGURE 33

GENERATING SYSTEMS OPERATION AND MAINTENANCE COST ESTIMATES (1984)

		BIOMASS SYSTEM				DIESEL SYSTEM		
				OPERATION AND MAINTENANCE			OPERATION AND MAINTENANCE	
COMMUNITY	REQUIRED ELECTRICAL CAPACITY (kw)	TYPE	CAPITAL COST ($)	% CAPITAL COST	ANNUAL COST ($)	CAPITAL COST ($)	% CAPITAL COST	ANNUAL COST ($)
Armstrong	1,000	steam turbine	4,900,000	9	441,000	1,729,000	10	172,900
Fort Hope	500	steam engine	2,505,600	8	200,448	1,060,000	15	159,000
Weagamow	300	steam engine	1,383,500	8	110,680	798,000	13	103,000
Gull Bay	200	steam engine	976,000	7	68,320	585,000	12	70,200

Note: The percentages applied to capital costs take into account power plant staffing regulations and locations and size of systems.

vi) Employment Created

The number of people which may be employed and the wages generated in each community in 1984 are summarized in Figure 34.

FIGURE 34

EMPLOYMENT CREATED

COMMUNITY	NUMBER OF PERSONS EMPLOYED			NUMBER OF PERSON YEARS	WAGES
	BIOMASS SUPPLY	ENERGY PLANT STAFF	TOTAL		
Armstrong	6	5	11	5.25	264,000
Fort Hope	14	5	19	13.30	227,600
Weagamow	14	5	19	14.00	302,360
Gull Bay	6	5	11	10.25	233,000

The employment estimates for Fort Hope and Weagamow are for an integrated forest harvesting operation which would include harvest of biomass, fuelwood and sawlogs.

vii) Economic Analysis

The preliminary economic analysis, conducted by the Ontario Ministry of Energy, revealed that payback on a wood biomass fuelled cogeneration system installed in Fort Hope may occur within three years. However the payback on wood biomass generating systems installed in Armstrong, Weagamow and Gull Bay may not occur within the 20 year projection period of this study.

7.9 Environmental Impacts

Wood Biomass

The harvesting of wood biomass at Armstrong and Gull Bay will consist of the salvage of residues, dead and dying trees and unmerchantable hardwood species from existing forest harvesting operations. This salvage will facilitate silviculture and reforestation practices.

The harvesting of wood biomass at Fort Hope and Weagamow will consist of harvesting of fire-killed stands and stands of overmature poplar and birch. Harvesting will be conducted using the small clear-cut method and the biomass will be hauled on a winter road network. The harvesting of fire-killed and overmature stands will facilitate good forest management practices.

No significant environmental impacts should result directly from the harvesting, processing or transportation of wood biomass at the study communities.

Peat

Armstrong is the only study community for which peat was considered as a source of biomass fuel. Two potential environmental impacts were identified which may result from development of the primary peatland in the area (north of airport). This peatland is reported (M.N.R.) to be located adjacent to a caribou wintering ground. Also the Whitesand River is reported (M.N.R.) to support a significant trout fishery. The outletting of drainage water from the peatland to the Whitesand River drainage system may affect the water quality and thus the trout fishery.

These potential impacts were primary factors in the decision that development of this peatland is not feasible using available dry mining techniques.

7.10 Administrative Framework

The following is a summary of the optimum administrative framework for each community.

	SUPPLY OF BIOMASS FUEL	OPERATION AND MAINTENANCE OF GENERATING SYSTEM
Armstrong	-supply by existing forest harvest operators, i.e. Great Lakes Paper Co., Domtar Inc., under contract to the system operator.	-Ontario Hydro
Fort Hope	-Band develop business to conduct forest harvesting operations.	-existing Fort Hope Power Authority
Weagamow	-Band develop business to supply biomass fuel under contract to the system operator.	-Ontario Hydro
Gull Bay	-Kiashke River Native Development Inc. - Band owned forest harvesting operation supply biomass fuel under contract to system operator.	-Ontario Hydro

7.11 Summary of Conclusions and Recommendations

Of the 43 remote communities investigated, Fort Hope, Armstrong, Weagamow and Gull Bay, listed in order of descending potential, have the highest potentials for economically viable operation of biomass fuelled generating systems. Under the E.M.R. Remote Community Demonstration Program, 41 communities are considered remote.

Sufficient sources of wood biomass are available within economical haul distances of these communities to permit supply of wood biomass fuel on a sustained yield basis.

The supply of wood biomass to each of the study communities is technically viable using available technology.

With the exception of Armstrong, fire tube boiler/steam engines are the optimum type of biomass fuelled generating system for the study communities. At present, water tube boiler/steam turbines appear to be the optimum system for Armstrong. However a gasifier/dual fuel engine could be installed when successful demonstration of the technology has been completed and if determined to be economically competative.

The 1984 cost per green tonne of wood biomass fuel delivered to generating systems in each of the study communities was estimated to be $23.23 in Armstrong, $26.40 in Fort Hope, $33.66 in Weagamow, and $34.50 in Gull Bay. Generally, the cost per tonne of biomass increases with a decrease in the volume required.

Fort Hope is the only study community for which use of biomass fuel presently appears to be economically advantageous over use of fuel oil. The use of biomass fuel in Armstrong appears to become advantageous between the years 1998 and 2003. The use of biomass fuel does not appear to become advantageous in Weagamow or Gull Bay within the 20 year projection period of this study.

In all of the study communities the cost to install biomass fuelled generating sytems is greater than that to install comparable capacity diesel fuelled systems. The additional cost per kilowattt is lowest in Fort Hope.

With the exception of Gull Bay, the operation and maintenance costs for biomass fuelled generating systems would be greater than for diesel fuelled systems. In Gull Bay, the costs would be comparable.

The installation of biomass fuelled generating systems would

result in the creation of between 11 and 19 jobs which would generate between $227,000 and $302,000 in wages annually in each of the study communities.

The primary objective of this study involved determination of the cost of biomass fuel delivered to generating systems in the study communities. In addition some of the related economic considerations have been evaluated at a prefeasibility level. Prior to installation of a biomass fuelled generating system a community specific detailed economic feasibility study should be conducted. This study should include: evaluation of the employment and wages created; the revenue which may be generated through development of an integrated forest harvesting operation (i.e. biomass, fuelwood and lumber); and the effect on Unemployment Insurance Commission and welfare transfers.

The lack of a coordinated policy for the investigation, installation and operation and maintenance of alternative energy supply systems in remote communities creates a barrier to the use of these systems. The government agencies responsible for energy supply in these communities should cooperate in the development of such policies. Policies should also be established for the provision of incentives to encourage communities to pursue the installation of alternative energy systems where these systems are determined to be economical. These incentives may be in the form of wage subsidies for employment created or reduced power rates or increased levels of electrical service.

The appropriateness and economical viability of using biomass fuelled generating systems in remote communities are dependent upon a number of factors. Some of these factors are: the existing population; economic development and physical structure of the community, the anticipated

population growth and economic development; the potential for cogeneration; the availability and cost of biomass fuel; interest of the community members; future cost of diesel fuel; and development of biomass energy systems technology. It is necessary to evaluate these and other factors to determine the appropriateness and economical viability of biomass fuelled generating systems for a particular community. However, it appears as if use of biomass fuelled generating systems may presently be economical in Fort Hope and may become economical in Armstrong between the years 1998 and 2003. Evaluation of the previously mentioned criteria may result in identification of other communities which exhibit similar appropriateness and economical viability to Fort Hope and Armstrong.

APPENDIX A

EVALUATION CRITERIA FOR RECONNAISSANCE LEVEL STUDY COMMUNITIES

...c: The rating system used is described on the following pages.

...OMMUNITIES	Wood Biomass Potential (max 5) & Comments	Peat Potential (max 5) & Comments	Social and Community Rating (max.5) & Comments	Access for Generating System Equipment (max 2.5)	Availability of Construction Equipment (max 2.5)	Combined Wood Biomass Rating (max.15)	Combined Peat Rating (max.15)
...RMSTRONG	5 - excellent forest resources - existing forest harvest operations will provide sufficient residues to supply biomass system.	4 - numerous peatlands in area contain fuel grade peat.	4 - pop. 850 - improved electrical service and reduced rates high priority - no local government capable of managing system.	2.5 - excellent access by highway, rail and all-weather landing strip.	2.5 - full range of equipment available.	14	13
...ULL BAY	5 - excellent forest resources - existing forest harvesting operations provide sufficient residues to supply biomass system.	3 - two deposits identified - peat not investigated as fuel source.	3 - pop. 425 strong Band leadership - interested in economic development opportunities.	2.5 - excellent access by highway.	2.5 - wide range of equipment available or can be easily accessed.	13	11
...RT HOPE	5 - excellent forest resources - Forest Resource Inventory mapping available.	3 - shallow discontinuous peatlands in area.	4 - pop. 750 - strong leadership - presently operate own electrical generation and distribution system.	2.0 - winter road maintained by Band Council when conditions and demand warrant.	2.5 - wide variety of equipment available.	13	11
BEARSKIN LAKE	5 - potential for increased use of forest resources excellent.	2 - shallow discontinuous peatlands - only potential peatlands susceptible to flooding of Severn River.	4 - pop. 336 in (1982) - strong leadership progressive community - not particularly interested in biomass technology.	1.5 - cat track maintained by Band when conditions and demand warrant.	2.5 - wide variety of equipment.	13	10
...WEAGAMOW (Round Lake)	4 - excellent forest resource potential.	1 - no potential peat deposits.	4 - pop. 530 in (1983) - strong leadership - previous logging and sawmill experience - progressive community.	2 - well maintained winter road.	2.5 - wide range of equipment available.	12.5	9.5
COLLINS	5 - forest resource potential excellent, should produce sufficient biomass to support generating system.	3 - small assumed shallow peatlands, access across rugged terrain.	4 - pop. 100 in (1982) - small community operates own generating system.	2.5 - rail access.	0.5 - very limited variety of equipment available.	12	10

Potential Biomass Feedstock	Anticipated Relative Biomass Cost	Cogeneration Potential & Comments	Existing Energy System (capacity and operating cost)	Diesel Fuel Cost	Estimated Energy Requirement & Recommended Biomass System	Potential Economic Benefits
- wood biomass and/or peat.	- wood biomass low - peat, high.	high - D & L Estates, & Whitesand Band commercial and institutional development.	- Ontario Hydro 350 kw - (1981) cost,$213,117 revenue, $227,280 profit, $14,163 - D & L Estates 250 kw	- Ontario Hydro 30¢ per litre - D & L Estates 33¢ per litre.	- 1,000 kw - recommended two/500 kw units - fire tube boiler/turbine or gasifier/ dual fuel engine.	- high due to present high rates and low cost of wood biomass fuel - will create employment and may stimulate economic development.
- wood biomass.	low	high	- Ontario Hydro two/150 kw - (1981) cost, $46,039 revenue, $11,208 loss, $34,831	- Ontario Hydro 35¢ per litre - 61¢ per litre at community.	- 300/kw - two/150 kw boiler/steam engines.	moderate
- wood biomass.	low	high - well clustered community development.	- Fort Hope Power Authority one/250 kw one/175 kw stand - by - fuel cost $100,000 per year.	- 64¢ per litre	- 500 kw - two/250 kw boiler/steam engine.	- potential economic benefits high - high cost diesel fuel replaced by low cost biomass - good co-generation potential.
- wood biomass.	high	low - due to scattered community development.	- Ontario Hydro new generating and distribution systems - 3 units ranging from 75 to 185 kw - operating cost not available.	- 77¢ per litre.	- 150 kw - boiler/steam engine.	- significant potential benefits due to high cost of diesel fuel, however biomass and training costs may also be high.
- wood biomass.	moderate	high - well clustered community development.	- Ontario Hydro 300 kw - operating cost in (1982) cost, $223,561 revenue, $104,819 loss, $118,742	- 69¢ per litre.	- 150 kw boiler/steam engine.	- high potential cost economic - cogeneration increases economic benefits.
- wood biomass.	- utilization of wood biomass not practical until large scale forest harvest operations commence, then biomass from residues available at low cost.	low - existing community development well clustered however potential limited due to small size of community.	- Collins District Area School Board 30 kw - CNR independent two/40 kw units.	- 67¢ per litre.	- estimated requirement for community excluding CNR 100 kw - biomass system not recommended however, steam engine would be most appropriate.	- potential economic benefits minimal.

APPENDIX A (cont'd)

Rating of Biomass Utilization Potentials

The following criteria were evaluated for each community and rated as described below:

i) Wood Biomass Potential

1 nil	to	5 excellent
- no potential due to lack of resource, inaccessible, or prohibitive regeneration periods.		- large reserves in excess of fuelwood requirements, in conjunction with existing forest extraction operations.

ii) Peat Potential

1 nil	to	5 excellent
- no potential peat deposits proximate to community.		- large reserves for which detailed data available, proximate to community.

iii) Social and Community Rating

1	to	5
- poorly developed community structure or lack of interest in alternative energy supply.		- well organized community with strong leadership interest in alternative enery supply.

iv) Accessibility For Generating System Equipment

1 - no access

2 - float and ski plane only

3 - all weather airstrip

4 - winter road and/or summer barge service

5 - all weather road and/or rail

v) Availability of Heavy Construction Equipment

1	to	5
- no equipment available		- wide range of Band owned equipment

APPENDIX A (cont'd)

vi) Combined Ratings

Combined Peat Rating:
This rating consists of a total of the ratings for peat, social and community, accessibility for generating system equipment, and availability of heavy construction equipment.

Combined Wood Biomass Rating:
This rating consists of a total of the ratings for wood biomass, social and community, accessibility for generating system equipment and availability of heavy construction equipment.

vii) Potential for Cogeneration

Cogeneration is the generation of power and heat concurrently. This type of energy configuration is most applicable in medium-sized installations using either steam engines or steam turbines. Its application in remote northern communities would be primarily to produce electricity, and for the heating of institutional and commercial facilities. Primary community requirements for cogenerating installations are a concentration of institutional and commercial facilities in settlements requiring 250-1000 kW of electrical power.

The potential ratings which appear in Table II are:

L - Low M - Medium H - High

This rating is not included in the combined peat and combined wood biomass rating, however potential for cogeneration was taken into consideration during final community selection.

APPENDIX B

Clarification of Technical Terminology and List of Abbreviations

CLARIFICATION OF TECHNICAL TERMINOLOGY

cord - 85 cubic feet of solid wood
- 128 cubic feet of stacked round wood
- one cord of green wood (50% moisture content) contains approximately 2 tonnes or 4,480 lbs., of wood.

cunit - one cunic contains 100 cubic feet of solid wood or 135 board feet.

hectare - one hectare equals 2.471 acres.

paracitic load - is defined as the energy consumed within a boiler house for auziliary uses (fans etc.) required to support the energy system.

tonne - one tonne equals 1.12 tons or 2,240 lbs.

wood biomass - in this report wood biomass is defined as forest fibre (i.e. logs, limbs, tops etc.) designated for use as fuel for energy production
- for the biomass fuelled energy systems in the communities investigated during this study the wood biomass would be fed into the boilers as chips.

LIST OF ABBREVIATIONS

cm - centimeter
- 0.01 meter
- 0.4 inches

kg - Kilograms
- 1,000 grams
- 2.24 lbs.

kw - kilowatt
- 1,000 watts of electrical power

l - litre
- 0.22 Imperial gallons

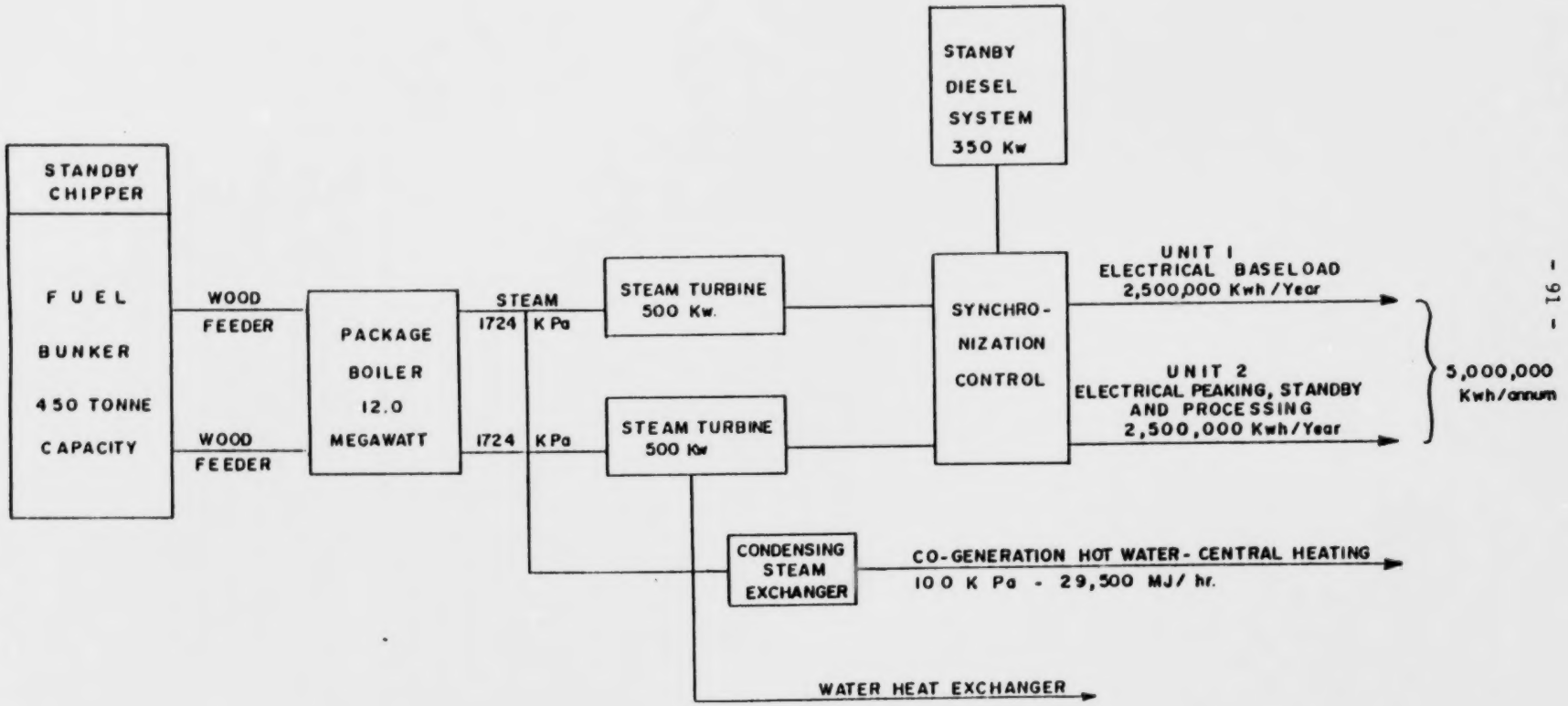
ARMSTRONG APPENDICES

(Ar-1 to Ar-13)

Appendix Ar-1

ARMSTRONG

WOOD BIOMASS CO-GENERATION SYSTEM


STANBY DIESEL SYSTEM 350 Kw
STANDBY CHIPPER
FUEL BUNKER 450 TONNE CAPACITY
WOOD FEEDER
WOOD FEEDER
PACKAGE BOILER 12.0 MEGAWATT
STEAM 1724 K Pa
1724 K Pa
STEAM TURBINE 500 Kw.
STEAM TURBINE 500 Kw
SYNCHRO-NIZATION CONTROL
UNIT 1 ELECTRICAL BASELOAD 2,500,000 Kwh/Year
UNIT 2 ELECTRICAL PEAKING, STANDBY AND PROCESSING 2,500,000 Kwh/Year
5,000,000 Kwh/annum
CONDENSING STEAM EXCHANGER
CO-GENERATION HOT WATER - CENTRAL HEATING
100 K Pa - 29,500 MJ/hr.
WATER HEAT EXCHANGER

Appendix Ar-2

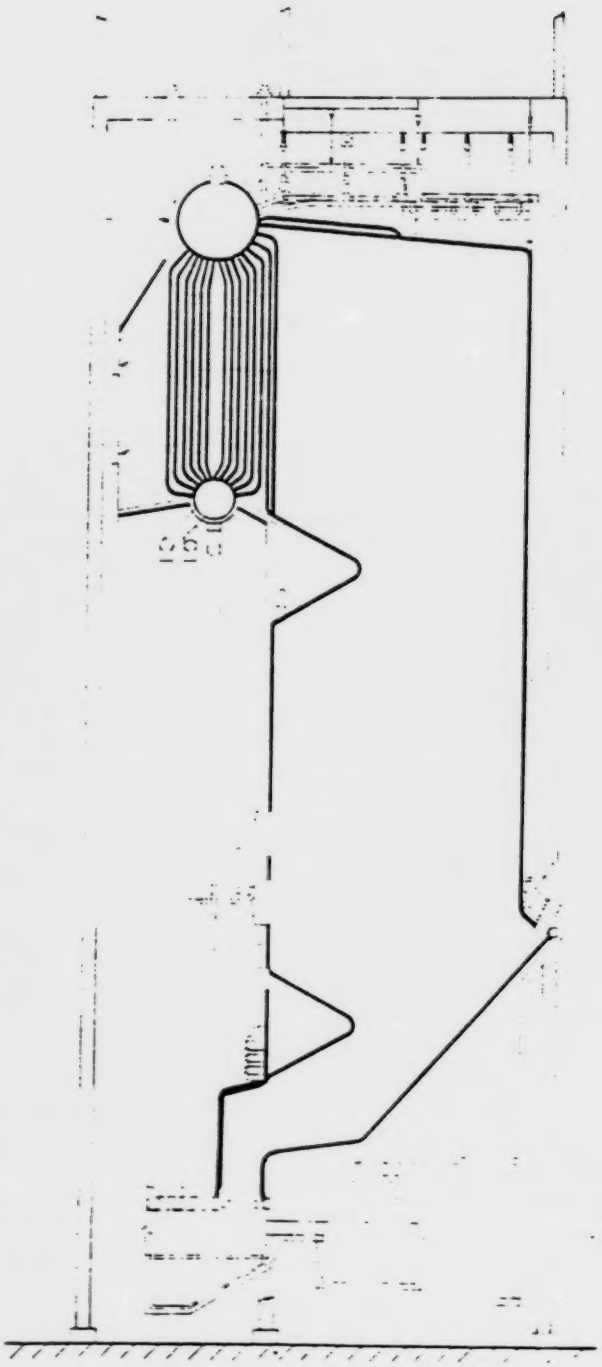
WOOD BURNING EQUIPMENT.

Changing fuel economics have enhanced the attraction of wood as a fuel and sophisticated wood fired steam generating equipment is now available to accomodate a growing number of users. Over the past forty years, Foster Wheeler has been in the forefront of the development of wood burning equipment. In addition to refinement in design and extension of application, there have been innovations in methods employed to most efficiently utilize this fuel and to meet environmental needs.

The burning of wood refuse requires the evaporation of moisture, the distillation and combustion of volatile components, and the combustion of remaining carbon materials. These three steps are accomplished either separately or simultaneously depending on the type of equipment installed. Foster Wheeler offers a variety of wood feeding, grate burning and ash removal techniques that may be used in a combination best suited for any particular installation.

FW waste wood boilers commonly include:

- Pneumatic spreader distributors with flat water cooled grates.
- Pneumatic spreader distributors with continuous ash discharge grates.
  The type of grate selected for a specific installation is a function of unit size, stack emission criteria, fuel sizing, provision for auxiliary fuels and economic considerations.
- Inclined Water Cooled Grate
  Steam generators for wood refuse firing may also employ an inclined water cooled grate which permits the wood refuse to slide into the furnace by gravity and such units are in wide-spread use. Wood refuse is dried as it slides down the grade and is burned near the bottom of the slope and on the horizontal portion. Ash is transported intermittently by steam jets and removed through discharge doors or dumping grate sections.



SKINNER SK-25

Horsepower to 2860 maximum (2133 kW)

Critical speed 8000 RPM

Wheel with 26" (660 mm) pitch diameter

Inlet 6/8" (152/203 mm) with optional side 12/14" (304/356 mm) exhaust

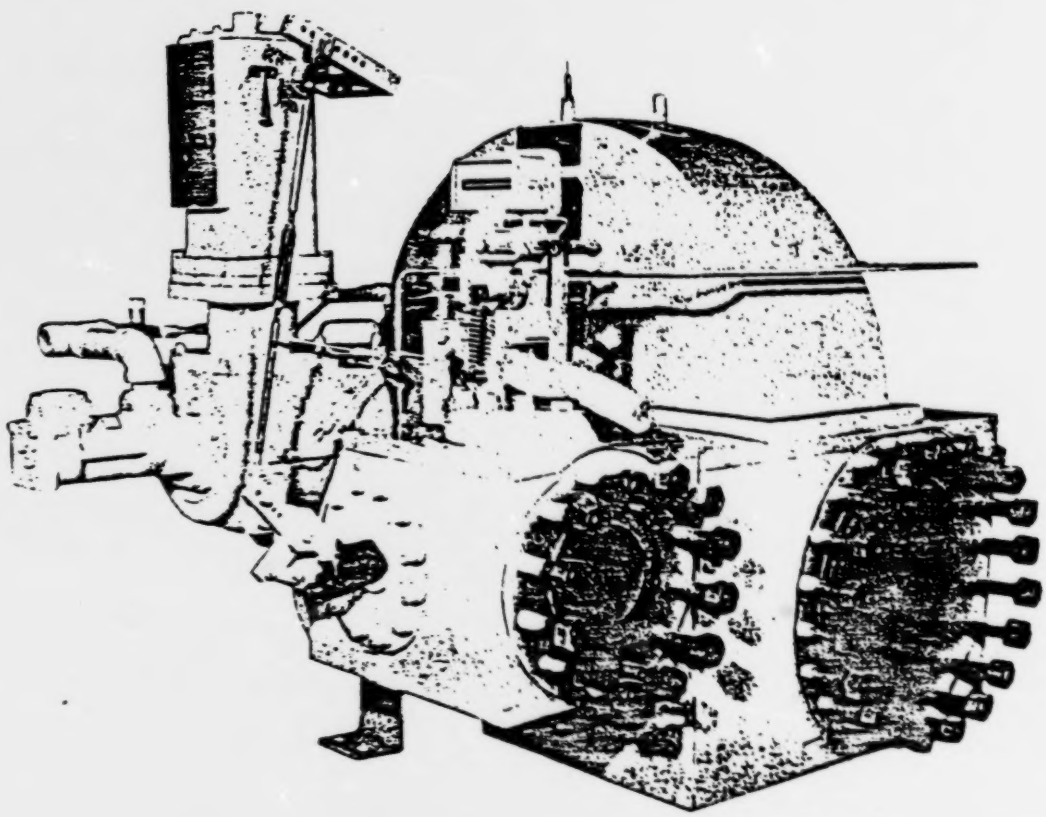
Speed to 5500 RPM

Exhaust pressure 28" vacuum (.068 bar) to 175 PSIG (12 bar)

Temperature to 900°F. (482°C)

Pressure to 900 psig (62 bar)

Available horizontal or vertical construction

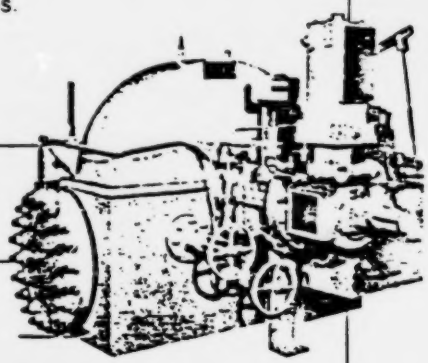


Appendix Ar-3

TURBINE MODEL SK-25

The new SK-25 mechanical drive turbine developed by Skinner Engine Company offers increased horsepower and speed, with higher inlet and exhaust pressures. Designed for increased efficiency and ease of maintenance it includes many superior construction features: 2 row velocity stage wheel, horizontal split construction for easy inspection and overhaul, ball thrust and radial sleeve type bearings, forced fed lubrication which greatly extends service life by minimizing friction and wear. Woodward speed controls for safer, more efficient operation.

1. Choice of Governors of the Woodward design.
2. Positive over-speed trip employing pin type construction.
3. Force fed oil lubricated bearings either shaft and/or motor driven.
4. Babbitt lined, insert sleeve type radial bearings.
5. Anti-friction ball thrust bearing.
6. Large packing boxes with up to 6 carbon rings in each box, stainless steel separators and large two-way acting garter springs.
7. Balanced, seated throttle valve.
8. Positive trip valve capable of being re-set under line pressure.
9. Integral steam strainer.
10. Water cooled bearing housing with inter-connecting piping.
11. Horizontally split casing.
12. True center line support.
13. Optional rotation, with inlet on right.
14. Optional exhaust location.
15. Condensing or non-condensing design. Horizontal or vertical configurations.



Automatic Start-up and Shut-down Systems
pneumatically or electrically actuated for remote operation

Safety Shut-down Systems
High and low lubrication oil pressure
High lubrication oil temperature
High exhaust pressure
High bearing temperatures
Electronic sensors for over-speed, wear and vibration
Remote alarm signals

Forced Feed Lubrication Systems
To all applicable specifications

Bearings
Tilting Pad thrust
Tilting Pad radial

Hand Valves
For partial load economy

Seal Piping
For condensing operation

Insulation and Jacketing
Fiberglass insulation with steel jacket to maintain temperature below 165°F (74°C)

Steam
Gauges and thermometers, indicating and/or recording
Flow monitors, indicating and/or recording

Tachometers
Vibrating reed, electric or electronic, indicating and/or recording.

Custom Designed Baseplates

Special Shaft Extensions

Special Materials

Domtar Forest Products

Appendix Ar-4

DOMTAR

P.O. Box 480,
Red Rock, Ontario, POT 2PO,
May 31, 1984.

Mr. J. Lundstrom,
President,
Armstrong Area Chamber of Commerce Ltd.,
ARMSTRONG, Ontario, POT 1AO.

Dear Sir:

This is in reply to your letter expressing your concern that Domtar is not operating themselves on the Armstrong licence area.

For several years, Domtar did operate in this area. However in 1979, an agreement between Great West Timber, the Ministry of Natural Resources and Domtar was reached whereby Great West Timber, who required sawlog material for their Thunder Bay mill, agreed to be the prime operation in this area. This change increased the volume of wood being cut and the employment opportunities in the area. Great West Timber also agreed to supply Domtar with wood chips from their sawmill.

This arragement has worked well over the past few years and it is our intention to continue on this agreement.

It fulfills a need of Great West Timber with a wood supply for their sawmill in Thunder Bay. It satisfies the Ministry's requirements with regard to harvesting some of the overmature wood in the area and yet stays within the harvesting and allowable cut plans for the area. It assures Domtar of the volumes of wood fibre required for the Red Rock mill and it must benefit Armstrong by creating employment in the area.

It is possible that not all the labour force will live in Armstong due to the travelling distance from Armstrong to the work area, but I am sure that the community must benefit from an appreciable portion of the payroll in the form of purchasing of fuel, food, and other requirements.

I would expect that as future operations move north of Armstrong that your community will benefit even more than it is at the present time. I would expect that you will find additional families moving into the community.

If Domtar had continued to operate in Armstrong it would have been with a considerably lower labour force than is experienced with Great West Timber.

....2

Appendix Ar-4 (cont'd)

Mr. J. Lundstrom - 2 - Red Rock, Ont.
cont'd.

So that your concerns will be known to Great West Timber, I have taken the liberty of sending them a copy of this correspondence.

Again we thank you for your letter and we trust we have explained our intentions to your satisfaction.

Yours very truly,

DOMTAR FOREST PRODUCTS,

B.E. JARVIS,
Woods Manager.

BEJ:nmb
cc: T.E. Inglis, Great West Timber

Appendix Ar-5

• CHEMICAL RESEARCH AND ANALYSIS
• CONTRACT LABORATORIES

TECHNICAL SERVICE LABORATORIES
DIVISION OF BURGENER TECHNICAL ENTERPRISES LIMITED
1301 FEWSTER DRIVE, MISSISSAUGA, ONT. L4W 1A2
TELEPHONE (416) 625-1544
TELEX 06-960215

CERTIFICATE OF ANALYSIS

SAMPLE(S) FROM Bird and Hale Ltd
1263 Bay Street
Toronto Ontario
/
ATTn Bill Moore

REPORT No. T6706-1

SAMPLE(S) OF PEAT

Inv# 25838
P.O. /

	C-1	C-2	C-3	C-4	C-5
CEC equivalent of N per 100g dry sample	80	130	130	200	190
pH in H2O	4.9	5.5	5.5	5.6	5.4
pH in CaCl	5.0	5.3	5.0	5.0	5.1
Conductivity umho/cm	846	489	191	195	126
Rubbed Fiber %	93.4	21.9	16.2	23.1	16.4
Moisture %	88.6	91.9	89.4	91.7	88.7
Bulk Density g/cc	1.04	0.97	0.97	0.98	0.95
Absorption Value	7.79	11.44	8.42	11.04	7.83
Absorption Capacity	23.45	21.19	21.54	41.26	18.52
Dried Sample					
Ash %	6.9	7.4	7.0	9.4	7.4
Volatile %	73.1	69.6	63.6	61.7	65.3
Calorific Value (cal/g)	3790	4140	5270	4420	4640

Samples, Pulps and Rejects discarded after two months

DATE Aug 3/84 SIGNED P.E.Burgener

P.E.Burgener PEng.

CTA

Appendix Ar-5 (cont'd)

• CHEMICAL RESEARCH AND ANALYSIS
• CONTRACT LABORATORIES

TECHNICAL SERVICE LABORATORIES
DIVISION OF BURGENER TECHNICAL ENTERPRISES LIMITED
1301 FEWSTER DRIVE, MISSISSAUGA, ONT. L4W 1A2
TELEPHONE (416) 625-1544
TELEX 06-960215

CERTIFICATE OF ANALYSIS

SAMPLE(S) FROM Bird and Hale Ltd
1263 Bay Street
Toronto Ontario
/
ATTn Bill Moore

REPORT No. T6706-2

Inv# 25838
P.O. /

SAMPLE(S) OF PEAT

	C-1	C-2	C-3	C-4	C-5
otal arbon %	46.00	48.61	48.40	49.68	49.00
itrogen %	2.7	1.8	2.6	2.3	2.4
ulphur %-	<0.01	0.19	0.18	0.25	0.24
xygen (alculated) %	44.4	42.0	41.8	38.4	41.0
:N (alculated)	17.0	27.0	18.6	21.6	20.4

ples. Pulps and Rejects discarded after two months

Aug 3/84 SIGNED R. E. Burgener, PEng

CTA

Appendix Ar-5 (cont'd)

• CHEMICAL RESEARCH AND ANALYSIS
• CONTRACT LABORATORIES

TECHNICAL SERVICE LABORATORIES
DIVISION OF BURGENER TECHNICAL ENTERPRISES LIMITED
1301 FEWSTER DRIVE, MISSISSAUGA, ONT. L4W 1A2
TELEPHONE (416) 625-1544
TELEX 06-960215

CERTIFICATE OF ANALYSIS

SAMPLE(S) FROM Bird and Hale Ltd
1263 Bay Street
Toronto Ontario
/
ATTn Bill Moore

REPORT No. T6706-3

SAMPLE(S) OF PEAT

Inv# 25838
P.O. /

	C-1 ppm	C-2 ppm	C-3 ppm	C-4 ppm	C-5 ppm
Aluminum (Al)	1900	1600	1700	2000	1800
Iron (Fe)	1200	3200	1700	2700	2700
Calcium (Ca)	17000	27000	28000	32500	30000
Magnesium(Mg)	2000	2300	1600	1600	1400
Sodium (Na)	350	260	350	450	270
Potassium (K)	3000	1650	900	1000	900
Titanium (Ti)	100	110	120	170	160
Manganese (Mn)	150	290	15	30	30
Phosphorus(P)	600	800	380	270	270
Barium (Ba)	<20	<20	<20	<20	<20
Chromium (Cr)	<10	10	<10	20	.<10
Zirconium (Zr)	<10	<10	<10	<10	<10
Copper (Cu)	<10	<10	<10	<10	<10
Nickel (Ni)	<10	<10	<10	<10	<10
Lead (Pb)	270	80	150	120	200
Zinc (Zn)	60	60	<10	20	<10
Vanadium (V)	<10	20	20	20	20
Strontium (Sr)	35	45	50	50	40
Cobalt (Co)	<2	<2	<2	<2	<2
Molybdenum(Mo)	<5	<5	<5	<5	<5
Silver (Ag)	<20	<20	<20	<20	<20

Samples, Pulps and Rejects discarded after two months

DATE Aug 3/84 SIGNED P.E.Burgener PEng.

Appendix Ar-5 (cont'd)

• CHEMICAL RESEARCH AND ANALYSIS
• CONTRACT LABORATORIES

TECHNICAL SERVICE LABORATORIES
DIVISION OF BURGENER TECHNICAL ENTERPRISES LIMITED
1301 FEWSTER DRIVE, MISSISSAUGA, ONT. L4W 1A2
TELEPHONE (416) 625-1544
TELEX 06-960215

CERTIFICATE OF ANALYSIS

SAMPLE(S) FROM Bird and Hale Ltd
1263 Bay Street
Toronto Ontario
/
ATTn Bill Moore

REPORT No. T6706-4

Inv# 25838
P.O. /

SAMPLE(S) OF PEAT

	C-1 ppm	C-2 ppm	C-3 ppm	C-4 ppm	C-5 ppm
Cadmium (Cd)	<5	<5	<5	<5	<5
Beryllium (Be)	<5	<5	<5	<5	<5

Reject Rules and Rejects discarded after two months

E Aug 3/84 SIGNED P.E.Burgener PEng.

Appendix Ar-6

Bruks Chips — the Energy Alternative for the Future

For thousands of years mankind has depended upon the forest for fuel – from the times of the open fire to the period of wood stoves and wood-fueled boiler plants. However, wood-burning in the past always meant toil and bother.

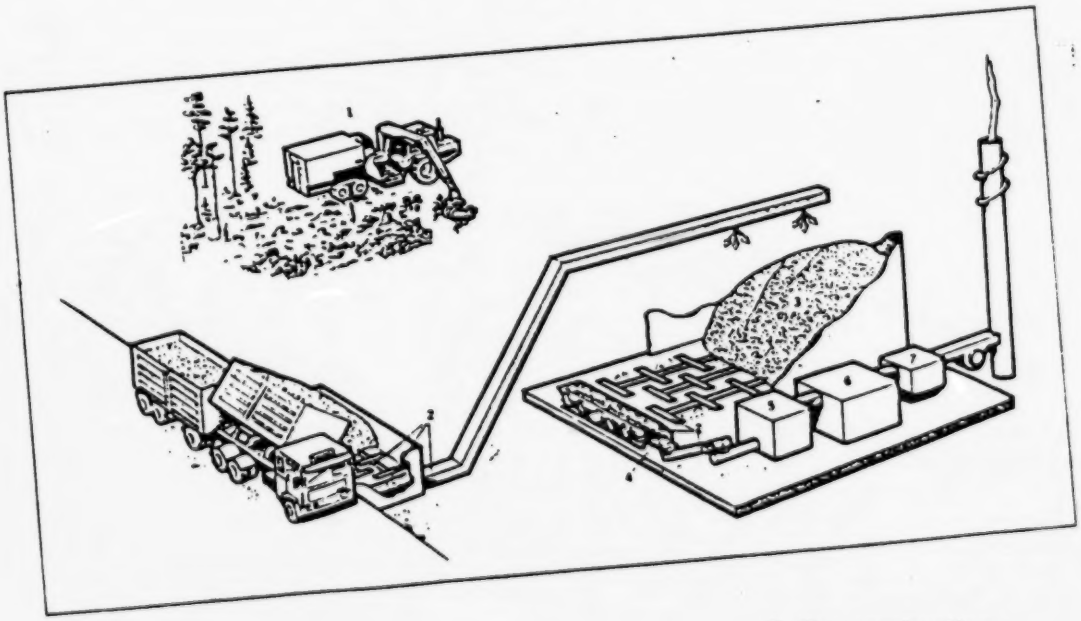
Today things have become easier. Bruks has developed a system for chip-heated boiler plants which, thanks to the adaptability of its heating effect, by far outclasses most of the existing alternatives. Our know-how has given us a leading position.

The forest, as a source of energy, holds unlimited possibilities. It is quickly renewable and will, if wisely managed, be able to satisfy our needs indefinitely: with the kind of fuel that in modern times was believed to be mere waste.

Bruks' tailor-made systems for biomass fuels give you a high degree of combustion efficiency and a heating effect which leaves former wood heating methods far behind.

And then the benefits for the productivity of our forests: The removal of logging residue – by chipping it – leads to reduction of fire hazard and to more satisfactory regeneration, and planting can be undertaken earlier than if the slash were left on the ground. Clearing and thinning of young forests are part of forest management that increases overall productivity.

So the investment in forest energy entails numerous advantages. Only one of them is that you can rely on Bruks' proven techniques providing you with well-conceived and systematic solutions from the forest to the furnace.



1. Mobile chipping system 1001 CT
2. Feeding system
3. Fuel silo
4. Vibrating conveyor with built-in screen
5. Pre-combustion chamber
6. Boiler
7. Cleaner unit

Chip Harvesting Unit 1001 CT

Bruks chip harvesting unit consisting of:

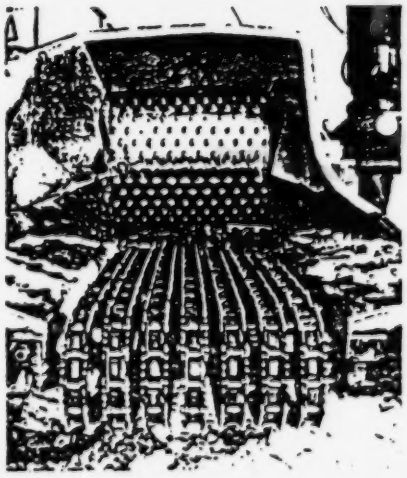
- Chipper
- Feed works
- Driving unit
- Chip bin

Chipper Type 1001 CT

Drum chipper with fan blades on the drum end plates for blow-out discharge of chips.

Infeed consisting of a horizontally fed basic feed work to be supplemented with a chain feeding deck as below. Infeed equipped with two feed rollers. The upper roller is driven hydraulically, the lower roller by a chain drive from the feeding deck.

Infeed unit can be raised into



Chain Feeding Deck

Feeder especially designed for feeding clear cut residue, parts of trees, and whole trees (max. Ø 35 cm).

Feeding deck equipped with 7 toothed chains driven by a directly mounted hydraulic motor. Chains run on spring steel guides so as to be easy on the feeder bottom.

The feed works are reversible. Forward/Stop/Reverse are activated manually but the infeed is controlled by an automatic capacity control which interrupts the infeed when the engine is overloaded, at the same time preventing jams in the chip tube (resulting from too low chipper drum rpm).

Chip Tube

Chip tube between chipper and chip bin; with built-in oversize eliminator so that only acceptable chips can pass on to the bin.

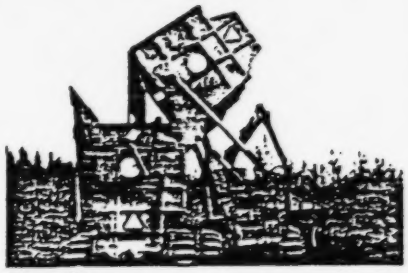
Drive for Chipper Drum

Complete drive consisting of diesel engine with dry disc clutch and power transmission via belt type powerband between engine and chipper.

Hydraulic System

The harvesting unit is hydraulically self-sufficient. The hydraulic pump is mounted on the power take-off of the engine.

All hydraulic valves are controlled electrically. Throttle and clutch are controlled pneumatically.



Chip Bin

Bin of welded steel plate, standard volume 18 m³. Bin high-tilting and dumping sideways for best sight control when dumping.

Control Panels

Separate control panel for throttle and clutch. Instrument panel with controls for chipper and engine. Complete with oil pressure and engine temperature indicators and automatic controls which cut off the engine if oil pressure drops or engine overheats.

Capacities

Type and positioning of raw material as well as the skills of the operator are, of course, decisive factors for the capacity of chip harvesting systems. The values below are averages based on a unit using raw material from softwood.

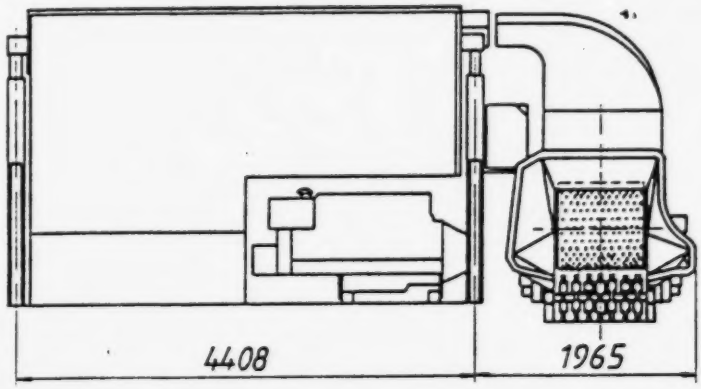
Chipping of clear cut residue, as left by processors, on the felling site: 17 m³ chips/h

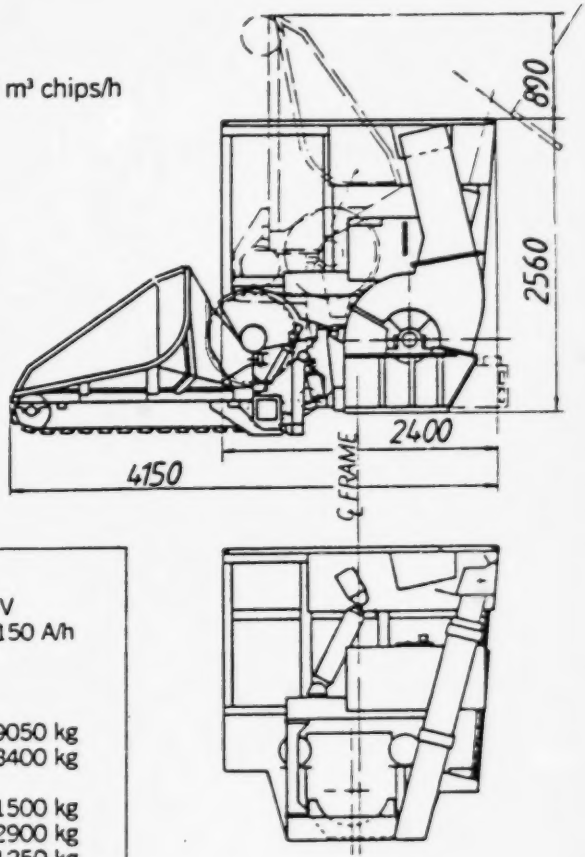
Chipping of more concentrated clear cut residue (larger heaps): 35 m³ chips/h

Chipping of thinning residue, trees and parts of trees: 60 m³ chips/h

Accessories

- Feed hopper: Alternative feeder for parts of trees and whole trees up to Ø35 cm. This alternative reduces weight as well as width of the harvester.
- Cleaner: For removal of needles, leaves and, to some extent, bark.
- Fire extinguishing system according to Swedish insurance regulations.





Data

Chipper drum diameter:	1000 mm	Electrical system:	24 V
Infeed opening, w×h:	780×420 mm	Battery capacity:	2×150 A/h
No. of chipping knives:	2		
Chip length:	20–40 mm, adjustable	**Weights**	
Chip bin dumping height: 2600 mm above chassis height. 150 mm displacement sideways.		Complete chip harvesting unit:	9050 kg
		Chipper and chip tube:	3400 kg
Diesel engine power:	Approx. 200 kW	Chipper drive (engine & clutch):	1500 kg
Fuel tank volume:	230 l	Chip bin, volume 18 m³:	2900 kg
Hydraulic system, volume:	Approx. 220 l	Chain feeding deck:	1250 kg
		Adaptation reduces weight of standard forwarder by approx. 1000 kg.	

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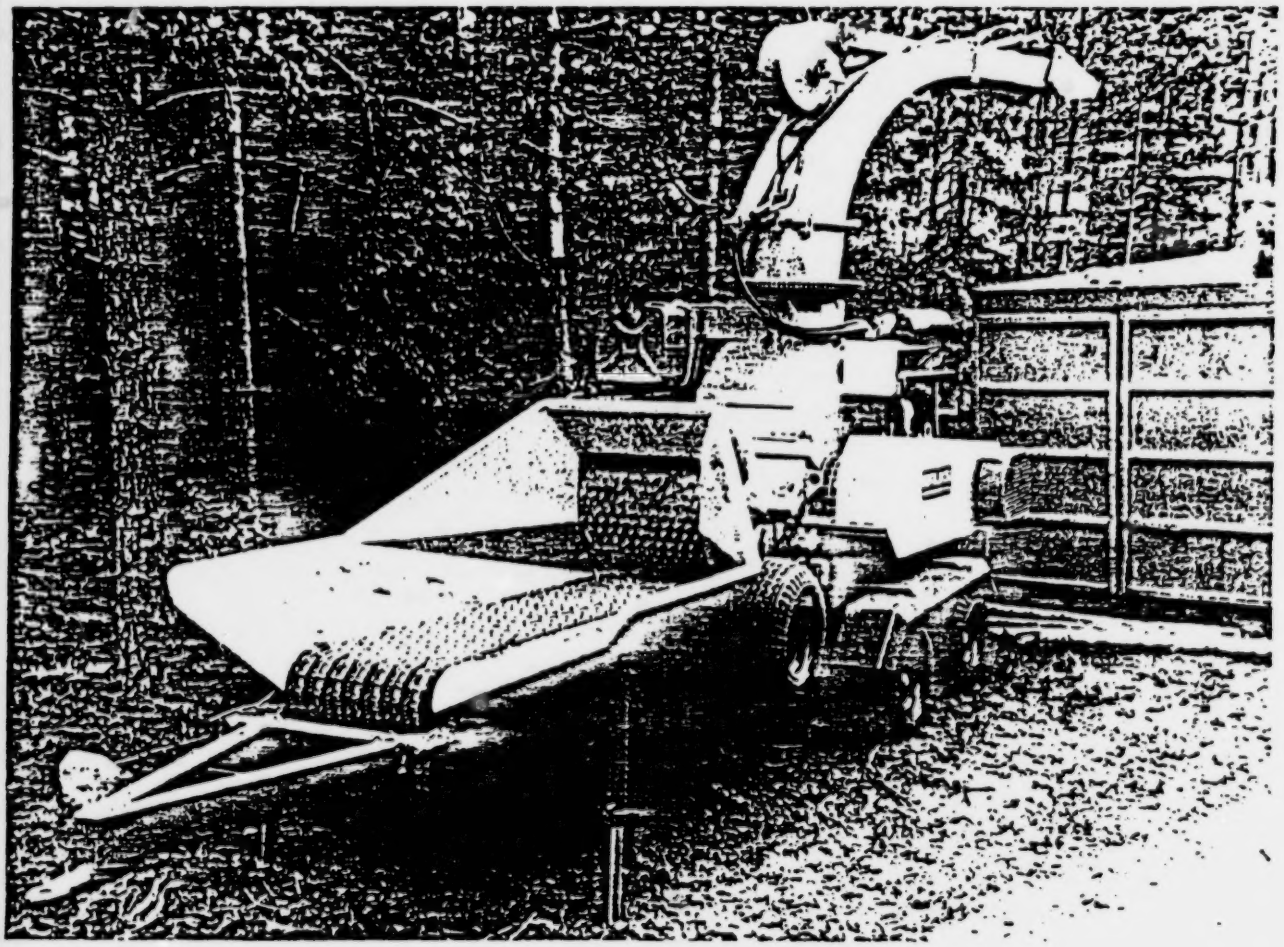
Chipping Unit 1001 CT Trailer



Unmanned chipping unit primarily designed for chipping material taken out by light forwarders from areas with poor (swampy) ground conditions or from thinnings.

Chipper Type 1001 CT

Drum chipper with fan blades on the drum end plates for blow-out discharge of chips.

Infeed consisting of a horizontally fed basic feed work supplemented with a chain feeding deck as below. Infeed equipped with two feed rollers. The upper roller is driven hydraulically, the lower roller by a chain drive from the feeding deck.

ing clear cut residue, parts of trees and whole trees.

Feeding deck equipped with 7 toothed chains driven by a directly mounted hydraulic motor. Chains running on spring steel guides to reduce wear on the feeder bottom.

The feed works are reversible. Forward/Stop/Reverse are activated manually but the infeed is controlled by an automatic capacity control which interrupts the infeed when the engine is overloaded, at the same time preventing jams in the chip tube (resulting from too low chipper rpm).

Chip Tube

Turnable chip tube equipped with ensures that only acceptable chips are blown on into containers/trailers.

Drive for Chipper Drum

Complete drive consisting of diesel engine with dry disc clutch and power transmission via belt type power band between engine and chipper. Engine cuts off automatically if oil pressure drops or engine is overheated.

Hydraulic System

Bruks 1001 CT Trailer is hydraulically self-sufficient. The hydraulic pump is mounted on the power take-off of the engine. All hydraulic valves are controlled electrically.

Radio-Control and Control Panel

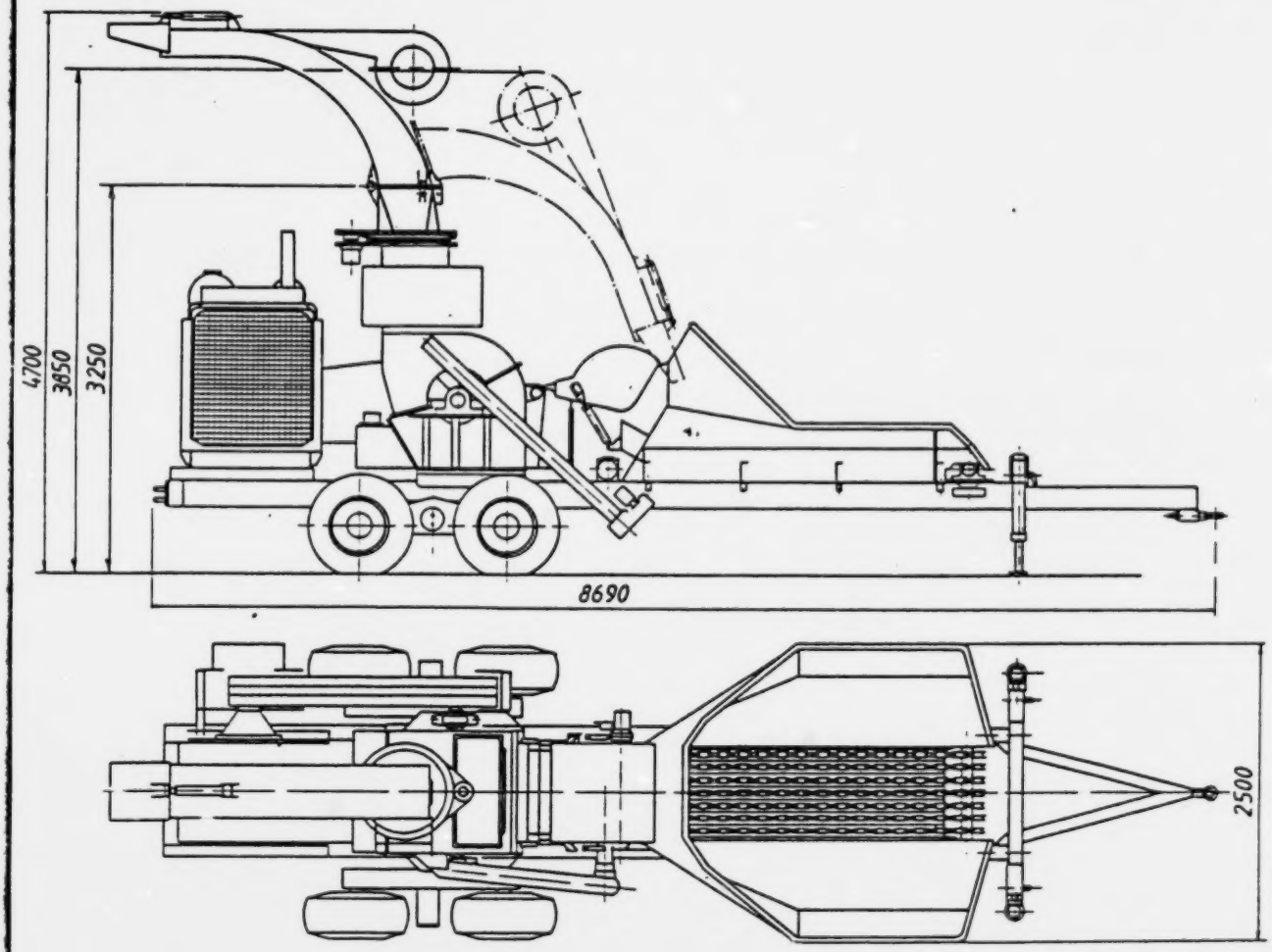
Completely mounted radio-controlled functions. Separate control panel with controls for chipper, engine, chip tube and trailer support legs, to be put into the operator's cabin of a light forwarder.

Trailer

Equipped with pivoting bogie, towing eyelet for tractor, and hydraulic support legs.

Data

Capacity:	Approx. 80 m³ chips/h	Diesel engine power:	Approx. 250 kW
Chipper drum dia.:	1000 mm	Fuel tank volume:	300 l
Infeed opening, w×h:	780×420 mm	Hydraulic system, volume:	Approx. 200 l
No. of knives:	2	Electrical system:	24 V
Chip length:	20–40 mm, adjustable	Battery capacity:	2×218 A/h
		Weight:	11600 kg



BRUKS
BRUKS MEKANISKA AB

EDP MACHINERY LTD.
1104 FEWSTER DRIVE • MISSISSAUGA, ONT.
L4W 2V7 (416) 625-9238 TLX • 06-960423

Appendix Ar-8

CAPITAL COST ESTIMATE
WOOD BIOMASS SYSTEM

A. Harvesting and Transportation	
Primary System	
1 Chip Harvester with Forwarder	$ 275,000
2 (used) High Cube Dump Trucks	60,000
Miscellaneous	15,000
Chipper Trailer	175,000
1 Dump Truck	30,000
Sub Total	550,000
B. Electrical Generating System	
Direct Costs	
Biomass Handling & Storage	225,000
Biomass Delivery to Boiler	60,000
Boilerhouse & Site Improvement (3,000 sq. feet)	180,000
Green Fuel Combustor with Water Tube Boiler (1200 HP) 250 psi with SH	1,200,000
Steam Turbine Generator with Generator Control Panel and Switch Gear (2) 500 kw	710,000
Boiler Feed Pump, Piping & Electrics	75,000
Condenser System	58,000
Stacking & Breeching	47,000
Services, Water Treatment, Sewage	90,000
Construction & Installation	175,000
Primary Steam Distribution System	50,000
TOTAL DIRECT COSTS	$3,425,000
Indirect Costs	
Engineering 10% T.D.C.	$ 342,500
Interest During Construction (6 months @ 15%)	198,000
Transportation	42,000
TOTAL INDIRECT COSTS	$ 582,500
Contingency 10%	$ 342,500
SUB TOTAL	$4,350,000
TOTAL ESTIMATED COST HARVESTING AND GENERATING SYSTEM	$4,900,000

Appendix Ar-9

PEAT HARVESTING METHOD

(Haku System)

1. Ditching
   - i) Drainage outlet ditch
   - ii) Perimeter and crossbog ditches

2. Surface Preparation
   - i) Clearing and overburden removal
   - ii) Rotivation
   - iii) Field grading

3. Production Ditches

4. Screw Profiling

5. Milled Peat Mining (Ridged Method)
   - i) Peat milling
   - ii) Spoon harrowing
   - iii) Ridging
   - iv) Transport to Storage Area
     - Loading
     - Transport

6. Transport to Generating System

Appendix Ar-10

DETAILS OF FUEL PEAT COST ESTIMATE

Assumptions

1. The Armstrong peatland #1 containing a 150 ha area of fuel grade peat is the subject property.
2. The 2-3 meters of surficial peat overburden are harvested and sold on a break-even basis.
3. One harvesting of fuel peat removes a 12 mm layer.
4. Each harvesting removes (per ha) 10,000 x 0.012 = 120 m^3 and @ 50% moisture content after solar drying the weight of peat is 120 m^3 x .5 = 60 tonnes per ha per harvesting.
5. Each harvesting season lasts from the end of May through the end of October or about six months.
6. Eight 12 mm layers are harvested per hectare per season or 480 tonnes/ha/year.
7. The average annual fuel peat requirement over the 20 year expected life of the generating system is 20,000 tonnes; therefore it will be necessary to harvest from approximately 42 hectares of the peatland each year.
8. The peatland has been calculated to contain 2.6 x 10 m^6 of fuel grade peat at greater than 90% moisture; therefore this represents approximately 1.3 x 10 m^3 @ 50% moisture content or 450,000 tonnes of fuel peat.
9. The expected life of the peatland is approximately 22 years.
10. Labour is readily available in Armstrong at an average cost of $4.00 per hour.
11. Power units purchased to prepare, harvest and transport the peat are operated on diesel fuel, costing 40¢ per litre.
12. All machinery, equipment and power units are purchased new, at the unit costs, numbers of units and total investment costs specified in Table 1.
13. All equipment was amortized at an annual interest rate of 12%, over the expected useful lifetimes indicated in Table 2, to give the amoritzed purchase costs (depreciation plus interest), and other fixed overhead charges shown in Table 2.

Appendix Ar-10 (cont'd)

14. Equipment operating costs were taken to be repairs and maintenance (based on the percentages of new costs shown in Table 3), fuels, lubricants and labour for operating and repairs, as portrayed in Table 3; repairs and maintenance are calculated on an annual basis; fuels, lubricants and labour are calculated on a hectare-12 mm-layer-harvested basis.

15. Peat bog development costs are amortized at 12% interest rate over the 20 year expected life of the generating system (i.e. this is equivalent to borrowing all development cost monies and repaying the loan over 20 years @ 12% interest); see Table 4.

Table 1: Equipment Requirements and (New) Purchase Costs'

Power Units	Number	Unit Cost	Total Cost
110 hp. bulldozer, wide tracks	1	$ 128,000	$ 128,000
210 hp. dump truck, 38m^3, tandem	1	64,000	64,000
rubber-tired loader, 4-W-D	1	45,000	45,000
150 hp. crawler tractor, wide tracks	1	98,000	98,000
75 hp. tractor, 4-W-D, duals	1	53,600	53,600
60 hp. tractor, 4-W-D, duals	3	38,000	114,000
Equipment			
ditcher	1	28,000	28,000
screw profiler	1	28,500	28,500
grader	1	11,000	11,000
miller	1	28,500	28,500
harrower	3	8,500	25,500
ridger	2	10,300	20,600
ridge loader	1	37,700	37,700
bog trailer	3	13,000	39,000
Total Equipment Investment Cost			$ 721,400

'Sources: Technopeat Inc., Montreal
Sheridan Equipment, Toronto
Robren Equipment, Waterloo
Massey-Ferguson Dealer, Elora

Note: cost includes shipping

Appendix Ar-10 (Cont'd)

Table 2: Equipment Useful Lifetimes and Overhead Charges

Equipment Item	Expected Useful Lifetime (Yrs.)	Amortized Purchase Cost[2]/year($)	Insurance Licences
Power Units			
bulldozer	7	30,850	1,280
dump truck	7	15,425	890
loader	7	10,840	450
crawler tractor	7	23,620	980
75 hp tractor	7	12,900	536
60 hp tractors	7	27,475	1,140
Equipment			
ditcher	7	5,450	280
screw profiler	10	5,550	285
grader	12	1,950	110
miller	10	5,550	285
harrowers	12	4,525	255
ridgers	12	3,660	206
rodge loader	7	9,090	377
bog trailers	10	7,600	390
Sub totals		$164,485	$7,465
Total Overhead Charges		$171,950	

[1] Sources: Technopeat Inc., Montreal
Ontario Ministry of Agriculture & Food, Toronto

[2] Based on 12% interest rate per annum, over the expected useful lifetime

Table 3: Equipment Operating Costs

Equipment Item	Repairs & Maintenance		Cost per ha-12 mm layer Harvested				
			Diesel Fuel		Lubricants	Labour	
	% of New Cost	Annual Cost	L/h	$/ha	$/ha	hr/ha	$/hr
Power Units							
bulldozer	8.0	$10,240	14	$ 5.60	$ 0.60	1.50	$ 6.00
dump truck	5.0	3,200	7	2.80	20.00	2.20	8.80
loader	7.0	3,150	14	5.60	0.55	1.25	5.00
crawler tractor	8.0	7,840					
75 hp tractor	5.0	2,680					
60 hp tractors	5.0	5,700					
Equipment							
ditcher	3.0	$ 840	45	$18.00	$ 2.00	4.50	$18.00
screw profiler	5.0	1,425	16	6.40	0.70	1.25	5.00
grader	2.5	275	12	4.80	0.35	1.10	4.40
miller	3.0	855	8	3.20	0.40	0.14	0.56
harrowers (x3)	2.5	640	6	2.40	0.20	0.30	1.20
ridgers	2.0	412	10	4.00	0.35	0.30	0.20
ridge loader	8.0	3,016	9	3.60	0.35	0.15	0.60
bog trailers	5.0	1,950	22.5	9.00	0.05	2.00	8.00
Sub totals		$42,225		$65.00	$25.75	14.59	$58.76
Total Operating Costs per ha-12 mm Layer Harvested (Fuels, Lubricants, Labour)							$164.00

Table 4: Peat Bog Development Costs and Peripheral Capital Items

Item	Cost	Amortized Cost/Year
Impact Assessment and Approval	$150,000	$ 22,760.00
Detailed Survey	75,000	11,380.00
Main drainage ditch	40,000	6,070.00
Perimeter & cross ditching[1] (@ 0.5 hr per ha $38.00/ha)	2,850	430.00
Surface Preparation - clearing (bush & surface peat @ $2500/ha)	375,000	56,900.00
Access Road - airport to bog	100,000	15,175.00
Peat Storage Pads	1,500	225.00
Equipment Service Building	60,000	9,100.00
Serviced Office Building	33,600	5,100.00
Fuel Depot	15,000	2,275.00
Hydro Service Upgrading	100,000	15,175.00
Totals	$952,950	$144,600.00

[1]Operating costs only-overhead charges for equipment already accounted for

Calculation of Cost per Tonne of Fuel Peat

a) Operating Costs

- Fuel, lubricants, labour @ $164.00 (Table 3) per ha-12 mm layer harvested x 8 layers harvested/season		$ 1,312.00
x 42 ha harvested		55,104.00
- Repairs & maintenance of equipment (Table 3)		42,225.00

b) Overhead Charges

- Amortized development costs/yr. (Table 4)	144,600.00
- Amortized equipment costs/hr. (Table 2)	164,485.00
- Insurance & other overheads/yr.(Table 2)	7,465.00
Total Operating and Overhead Costs/Year	413,879.00
Total Tonnage harvested (Assumption 8)/Year	20,000.00
Cost per tonne harvested and delivered to generating plant	20.70

Appendix Ar-11

DETAILS OF WOOD BIOMASS FUEL COST ESTIMATE

		Cost Per Green Ton	Total Cost
		$	$
1.	Road Maintenance - 2.40/cord x 13,000 cords	1.18	31,200
2.	Operator Cost for Chipper $400/day x 290 days	4.37	116,000
3.	Maintenance/Parts/Repairs for Chipper	0.53	14,000
4.	Cost of Knives for Chipper	0.09	2,400
5.	Fuel cost for Chipper 441/hr. x 2320 hrs. x $0.49/l	1.92	51,000
6.	Miscellaneous costs for chipping	0.19	5,000
7.	Trucking cost based on using two 26 cu.yd. box dump trucks @ $12/cord x 13000 cords	5.88	156,000
8.	Felling cost - $10/cord x 13,000 cords	4.90	130,000
9.	Crown Dues - $1/cord x 13,000 cords	0.49	13,000
10.	Chipper Rental	1.23/year	32,600/year
	Total Cost	20.78	551,200
11.	Company Supervision - $5/cord x 13,000 cords	2.45	65,000
	TOTAL COST	23.23	616,200

Appendix Ar-12

EMPLOYMENT POTENTIAL
WOOD BIOMASS SYSTEM

(based on 2000 hrs per year)

WORK ACTIVITY	NO. EMPLOYED	PERIOD OF WORK	HOURLY RATE($)	TOTAL WAGES ($)
A. PRODUCTION OF BIOMASS				
1. Forest Harvesting				
26,000 tonnes/year				
- Workers	3	3/4	12.00	54,000
- Foreman/Operator	1	1	14.00	28,000
2. Biomass Bunker				
- Workers	2	1	12.00	48,000
TOTAL HARVESTING & PROCESSING	6			130,000
B. ENERGY PLANT STAFFING				
Boilerhouse				
- Workers	4	1	13.00	104,000
- Boilerhouse Foreman	1	1	15.00	30,000
TOTAL ENERGY PLANT STAFFING	5			134,000
TOTAL A & B	11			264,000

Appendix Ar-13

ECONOMIC ANALYSIS DATA
-ARMSTRONG-
SOURCE: ONTARIO MINISTRY OF ENERGY

Biomass System :
Economic Assessment :
25 Year Life :

:Location: :Resource:
:Armstrong :Wood: Electricity

Input -
Base 1984 Costs

Capital Cost:	4900000
O & M:	441000
Diesel O&M:	172900
Diesel Cap. Costs:	1729000

Output -
Present Values

Expenses	6243359.
Revenue	-1182271
Rate of Return (less grant	-1.87853
Cost/kWh (diesel)	0.599283
Cost/kWh (biomass)	0.756717

Borrowing Structure Length of Term: 15 :

	Capital	Interest Rate	Yearly Payments	
Source 1	0	0.14	0	1
2	0	0.12	0	0
3	0	0	0	

Rates

Inflation	0.06
Discount	0.12

Real Value Table

Year	Expenses	Loan Pays	W/I	Fuel Cost	kWh	Bio. Cost	Revenue	PV Exps.	PV Rev.	Payback
1984	268100	0	0.3	297399	330443.3	474008	-176609	268100	-176609	
1985	284186	0	0.3225	326561	337530.7	511770	-185209	ERR	ERR	
1986	301237.1	0	0.345	355723	343693.7	549532	-193809	493881.9	-319868.	0
1987	319311.3	0	0.3675	384885	349102.0	587294	-202409	721161.4	-463939.	0
1988	338470.0	0	0.39	414047	353896.3	625056	-211009	936265.3	-599039.	0
1989	358778.2	0	0.428	465357.8	362428.1	667220.8	-201863	1139845.	-712581.	0
1990	380304.9	0	0.466	516668.6	369576.9	709385.6	-192717	1332520.	-810218.	0
1991	403123.2	0	0.504	567979.4	375647.7	751550.4	-183571	1514872.	-893256.	0
1992	427310.6	0	0.542	619290.2	380867.2	793715.2	-174425	1687456.	-963703.	0
1993	452949.3	0	0.58	670601	385402.8	835880	-165279	1850794.	-1023385	0
1994	480126.2	0	0.628	742974.8	394360.2	892545.2	-149570.	2005382.	-1071462	0
1995	508933.8	0	0.676	815348.6	402045.6	949210.4	-133861.	2151688.	-1109944	0
1996	539469.8	0	0.724	887722.4	408711.9	1005875.	-118153.	2290156.	-1140271	0
1997	571838.0	0	0.772	960096.2	414549.3	1062540.	-102444.	2421207.	-1163749	0
1998	606148.3	0	0.82	1032470	419703.2	1119206	-86736	2545237.	-1181497	0
1999	642517.2	0	0.886	1139545	428722.7	1195398.	-55853.4	2662622.	-1191701	0
2000	681068.2	0	0.952	1246620	436491.5	1271590.	-24970.8	2773719.	-1195774	0
2001	721932.3	0	1.018	1353695	443253.1	1347783.	5911.8	2878865.	-1194913	0
2002	765248.3	0	1.084	1460770	449191.2	1423975.	36794.4	2978377.	-1190129	0
2003	811163.2	0	1.15	1567845	454447.8	1500168	67677	3072539.	-1182271	0

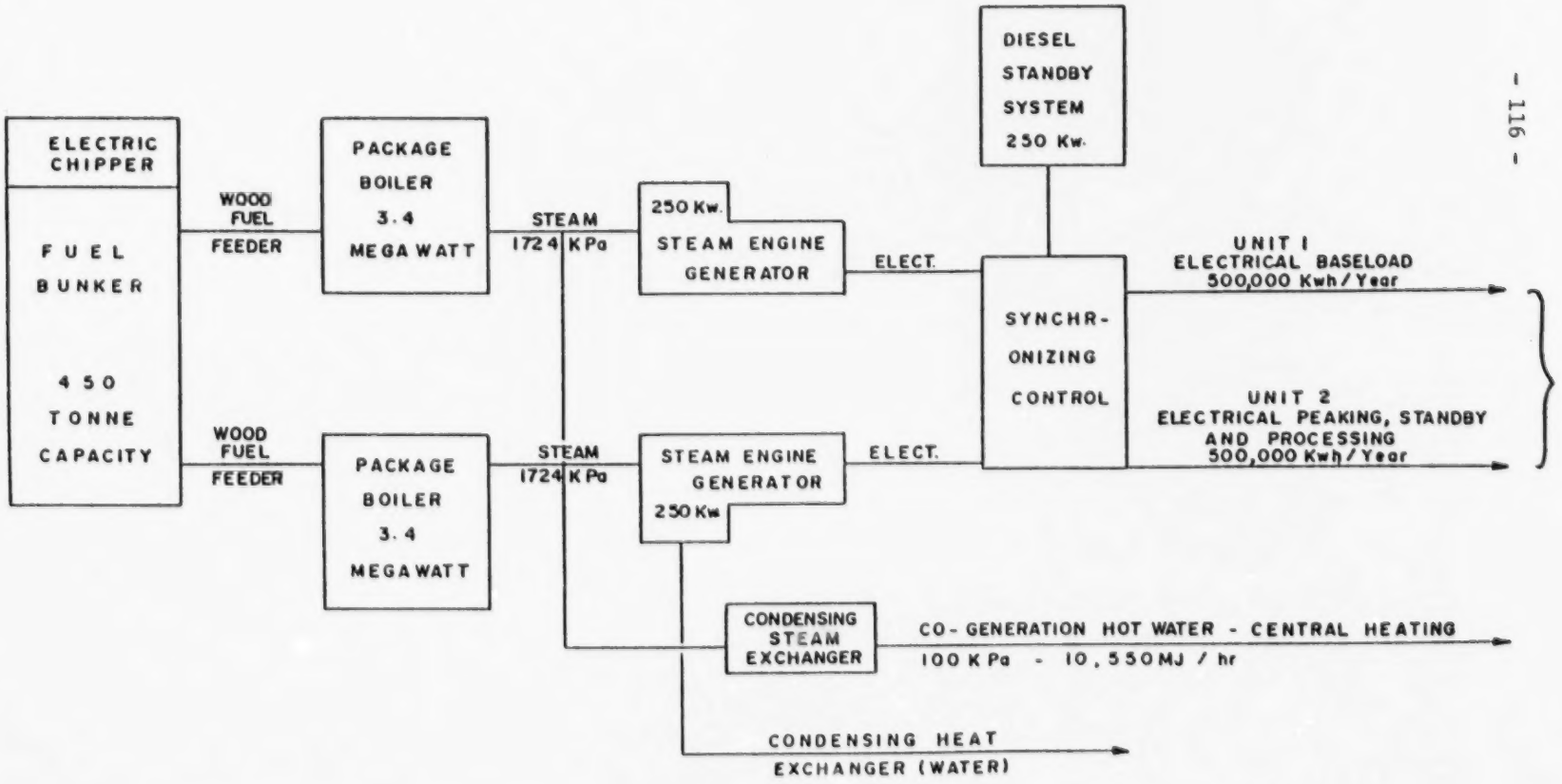
FORT HOPE APPENDICES

(FH-1 to FH-13)

APPENDIX FH-1

FORT HOPE

WOOD BIOMASS CO-GENERATION SYSTEM

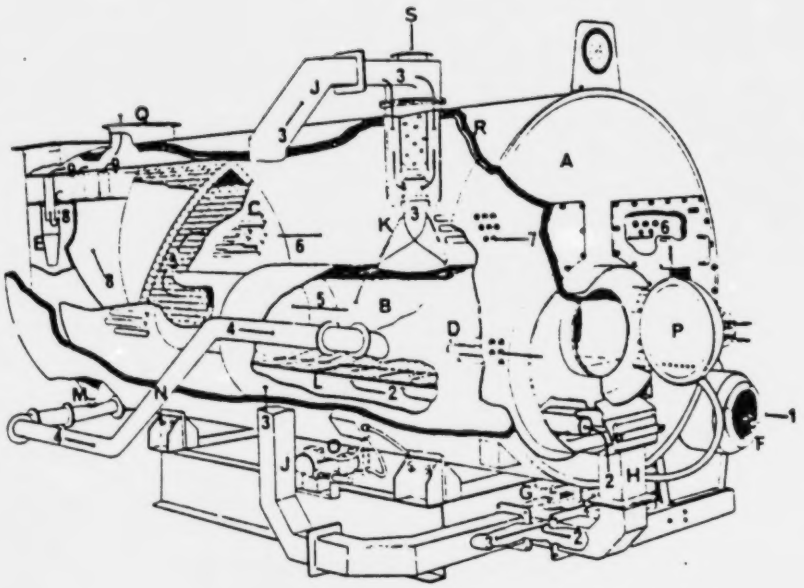

ELECTRIC CHIPPER
FUEL BUNKER
450 TONNE CAPACITY
WOOD FUEL FEEDER
WOOD FUEL FEEDER
PACKAGE BOILER 3.4 MEGA WATT
PACKAGE BOILER 3.4 MEGA WATT
STEAM 1724 KPa
STEAM 1724 KPa
250 Kw. STEAM ENGINE GENERATOR
STEAM ENGINE GENERATOR 250 Kw
ELECT.
ELECT.
DIESEL STANDBY SYSTEM 250 Kw.
SYNCHR-ONIZING CONTROL
UNIT 1 ELECTRICAL BASELOAD 500,000 Kwh / Year
UNIT 2 ELECTRICAL PEAKING, STANDBY AND PROCESSING 500,000 Kwh / Year
CONDENSING STEAM EXCHANGER
CO-GENERATION HOT WATER - CENTRAL HEATING
100 KPa - 10,550 MJ / hr
CONDENSING HEAT EXCHANGER (WATER)

Boiler Construction

APPENDIX FH-2

1. Air inlet.
2. Primary air supply (under grate)
3. Secondary air supply.
4. Grit transporting air.
5. Products of combustion leaving furnace.
6. Products of combustion in first pass smoke tubes.
7. Products of combustion in second pass smoke tubes.
8. Products of combustion entering grit arrester.
9. Products of combustion leaving grit arrester.

A Front of Boiler.
B Furnace.
C 1st pass (tubes).
D 2nd pass (tubes).
E Grit arrester.
F Fan.
G Modulating dampers.
H Underfire air.
J Overfire air.
K Fuel/air tube.
L Grate.
M Venturi.
N Grit re-firing tube.
O Master modulating control.
P Fire door.
Q Flue gas outlet.
R Boiler shell.
S Fuel inlet.



RATINGS AND DIMENSIONS OF VEKOS WOOD/COAL/OIL BOILERS

(Based on Kiln dried Hardwood Sawdust (7% moisture) with GCV of 8500 BTU's . lb.)

Model No.	Approximate Fuel Feed at 60° F	Rated Evaporation from and at 212° F		OVERALL DIMENSIONS			Tube withdrawal space required at front of boiler	No. of Furnaces
		lb. /hr.	B.T.U.'s /hr.	Length	Width	PNEUMATIC FIRING Height from Boiler Base to Cen. Line of Fuel Delivery pipe		
60	1,710	1,640	1,800,000	13' 0½"	7' 3½"	7' 4½"	8' 3"	1
80	2,300	2,480	2,421,000	13' 10"	8' 0½"	7' 11½"	8' 9"	1
100	2,876	3,100	3,013,000	14' 5½"	8' 1½"	8' 9"	9' 4½"	1
125	3,593	3,870	3,753,000	15' 10"	8' 2½"	8' 9"	10' 9"	1
150	4,340	4,680	4,544,000	16' 1"	8' 9"	9' 3½"	11' 0"	1
165	5,170	5,580	5,412,000	16' 4"	8' 10"	9' 7½"	11' 0"	1
200	5,760	6,210	6,026,000	18' 1"	9' 7½"	10' 3½"	12' 9"	1
215	6,875	7,420	7,202,000	18' 11½"	9' 7½"	10' 3½"	12' 9"	1
225	7,925	8,550	8,280,000	20' 3"	10' 1"	10' 5½"	14' 0"	1
250	9,590	10,350	10,026,000	20' 3"	10' 1½"	10' 6½"	14' 0"	1
260	10,420	11,250	10,908,000	22' 3"	10' 1½"	10' 6½"	15' 0"	1
300	12,100	13,050	12,650,000	22' 3"	10' 5"	10' 8½"	15' 0"	1
330	13,350	14,400	13,972,000	22' 3"	10' 5"	10' 8½"	15' 0"	1

Ratings of the Vekos waste fired boilers will vary with the type of waste used as fuel. For example. Green Hardwood sawdust and bark would be appropriately 89% of values shown above for Kiln dried sawdust.

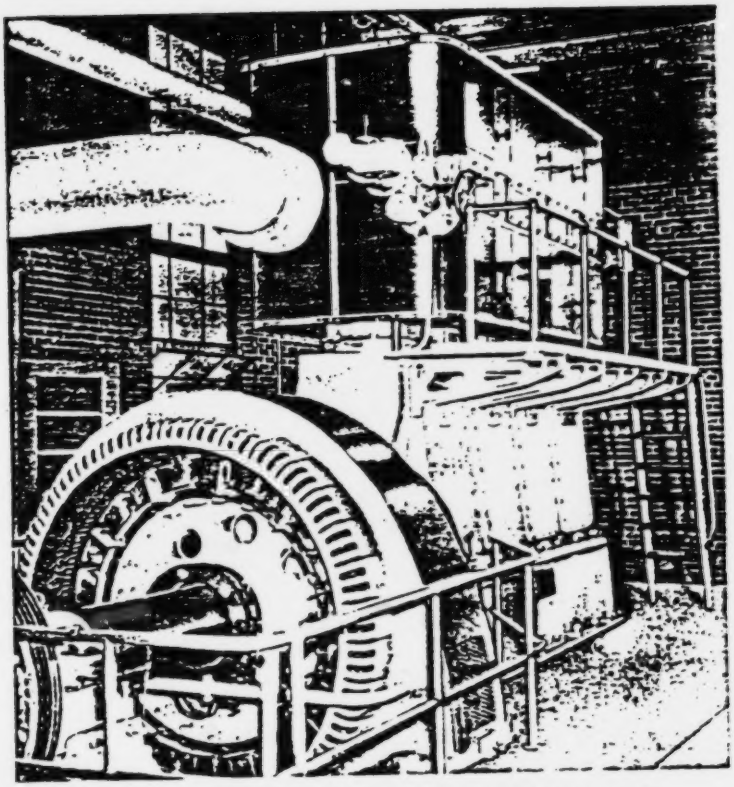
APPENDIX FH-3

Bulletin: STE-1280

SKINNER

UNIVERSAL UNAFLOW STEAM ENGINES

MULTI-CYLINDER • VERTICAL TYPE



FOR INDUSTRIAL AND MARINE APPLICATION

AVAILABLE SIZES:
300
TO
15,000
HORSEPOWER

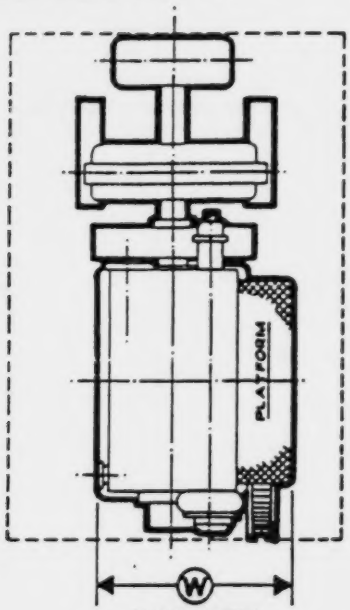
- MAINTAINED ECONOMY
- HIGH DEPENDABILITY
- LOW MAINTENANCE COST
- MAXIMUM ACCESSIBILITY

APPENDIX FH-3 (continued)

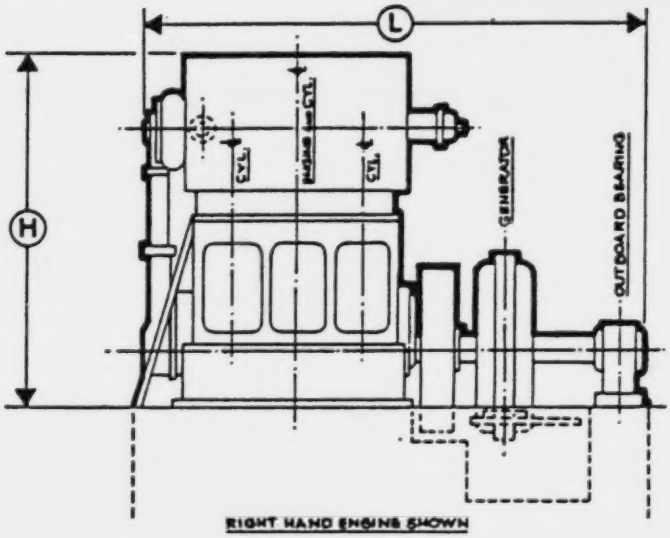
Progress Through Performance . . . That's SKINNER

SKINNER

STEAM ENGINE DESIGN DATA



PLAN VIEW



RIGHT HAND ENGINE SHOWN

ELEVATION VIEW

STEAM ENGINE TYPE			RV - FRAME (12" STROKE)		CV - FRAME (14" STROKE)		DV - FRAME (16" STROKE)	
NUMBER OF CYLINDERS			RV - 2	RV - 3	CV - 2	CV - 3	DV - 2	DV - 3
INDICATED HORSEPOWER		IHP	425	650	770	1150	980	1500
KILOWATT		KW	275	425	500	750	600	1000
ENGINE		RPM	400		360		327	
WEIGHT - ENGINE		LBS	29,000	40,000	44,000	50,000	49,000	62,000
WEIGHT - GENERATOR		LBS	6,200	8,600	9,500	11,500	11,000	15,000
WEIGHT - FLYWHEEL		LBS	7,000		7,000		10,000	7,000
DIMENSIONS IN INCHES/MILLIMETERS	WIDTH	Ⓦ	74/1880	76/1930	76/1930	84/2134	94/2388	
	LENGTH	Ⓛ	144/3658	176/4470	172/4369	204/5182	181/4597	211/5359
	HEIGHT	Ⓗ	116/2946		138/3505		151/3835	
CTR. SHAFT to FLOOR LINE			18/457		24/610		24/610	
PISTON REMOVAL SPACE			30/762		33/838		35/889	
	FLYWHEEL SIZE	INCHES ONLY	70 x 10		70 x 10		70 x 15	70 x 10
	OUTBOARD BEARING	INCHES ONLY	7 x 13		7 x 13		8 x 15	10 x 18
STD. FOUNDATION, CU. FT			700	840	1200	1350	1350	1500
DEPTH STD. FOUNDATION FT. (MM)			5 (1524)		6 (1829)		6 (1829)	

... SPECIAL CONDITIONS and REQUIREMENTS OTHER THAN THAT LISTED IN ABOVE TABLE.

... NOTE: SINGLE and DUPLEX ENGINES OF THE PISTON VALVE TYPE AVAILABLE ... BRAKE HORSEPOWERS FROM 13 to 300. PRICES and DESCRIPTION UPON REQUEST

... 5", 7", 8", 30" and 36" STROKE ENGINES ARE AVAILABLE. CHECK SKINNER ENGINE COMPANY

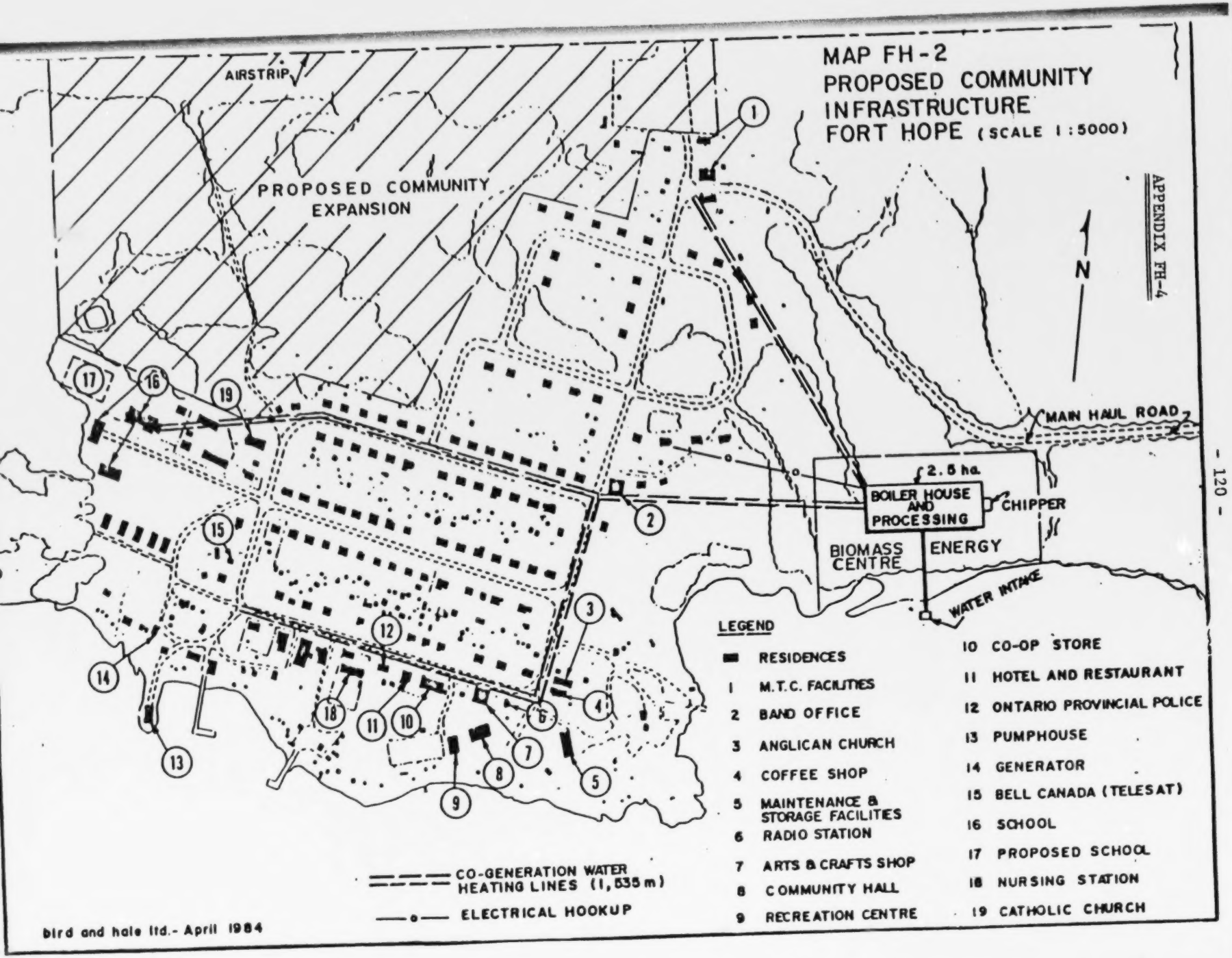
APPX. WATER RATE per KILOWATT HOUR
(DRY and SATURATED)
• TYPICAL EXAMPLES •

150 psig Inlet - 0# Back Press. - 31.7#/Kw.Hr.
150 psig Inlet - 12# Back Press. - 37.5#/Kw.Hr.
150 psig Inlet - 26" Vacuum - 21.7#/Kw.Hr.

300 psig Inlet - 0# Back Press. - 27.5#/Kw.Hr.
300 psig Inlet - 12# Back Press. - 30.0#/Kw.Hr.
300 psig Inlet - 26" Vacuum - 21.2#/Kw.Hr.

SEE BULLETIN STE-477 FOR STEAM ENGINE GENERATING SETS (ENERGEN - PAC) 4" TO 10" STROKE W/BRAKE HORSEPOWER TO 300.

SKINNER ENGINE COMPANY POWER DIVISION
A SUBSIDIARY OF BANNER INDUSTRIES, INC.


MAP FH-2
PROPOSED COMMUNITY
INFRASTRUCTURE
FORT HOPE (SCALE 1:5000)
APPENDIX FH-4
AIRSTRIP
PROPOSED COMMUNITY EXPANSION
N
MAIN HAUL ROAD
2.5 ha.
BOILER HOUSE AND PROCESSING
CHIPPER
BIOMASS ENERGY CENTRE
WATER INTAKE
LEGEND
RESIDENCES
1 M.T.C. FACILITIES
2 BAND OFFICE
3 ANGLICAN CHURCH
4 COFFEE SHOP
5 MAINTENANCE & STORAGE FACILITIES
6 RADIO STATION
7 ARTS & CRAFTS SHOP
8 COMMUNITY HALL
9 RECREATION CENTRE
10 CO-OP STORE
11 HOTEL AND RESTAURANT
12 ONTARIO PROVINCIAL POLICE
13 PUMPHOUSE
14 GENERATOR
15 BELL CANADA (TELESAT)
16 SCHOOL
17 PROPOSED SCHOOL
18 NURSING STATION
19 CATHOLIC CHURCH
CO-GENERATION WATER HEATING LINES (1,535 m)
ELECTRICAL HOOKUP
bird and hale ltd.- April 1984

APPENDIX FH-5

PROJECTED LOAD ANALYSIS

	Consumption kw/h	Winter High Loads kw
1. EXISTING LOADS		
a) Domestic Customers	19,049	
b) Commercial Customers		
- Community Services		
(Water System, Fire Protection)		
- M.T.C.		
- Bell Canada	27,766	
	46,815	208*

* Report of Proctor & Redfern - 1982)

2. PROJECTED LOADS (EXISTING & NEW)	Load Factor %	Winter High Loads kw	Total kwh
a) Domestic & Commercial (Expansion)	30	208	339,000
b) New School & Sports Complex	25	100	200,000
c) Sewage & Water (Pumping)	100	42	175,000
d) Cogeneration Pumping	100	25	219,000
e) Energy Plant (Parasetic)	26	50	80,000
f) Forest Complex	15	75	65,000
TOTAL		500	1,078,000

APPENDIX FH-6

KRABAT 232

A rugged and strong skidder. Exeptional in steep, rough or boggy conditions. Easy to handle, highly productive. Minimal maintenance.

Technical Specifications

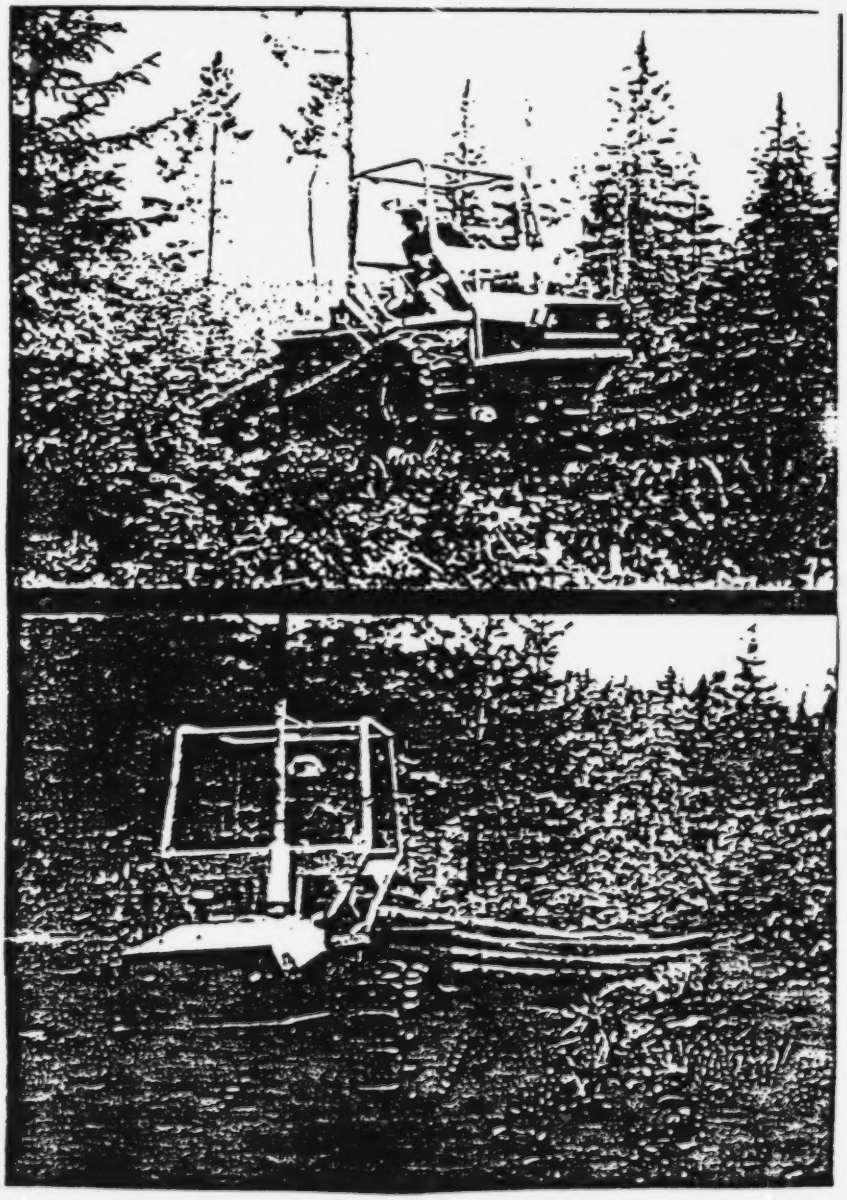
Engine:
2-Cylinder in V-configuration, aircooled through flywheel-fan. Four stroke cycle with direct combustion system.
Displacement: 1558 cm³ 95 cu in.
Max Output: HP 32 SAE at 2500 rpm,
Max. Torque: 8,5 kpm 61 ft.lb. at 2200 rpm.
Compression ratio: 1 : 20.
Injection Equipment: Robert Bosch.
Electric Starter: 2,5 HP.
A.C. Generator: 14 V 28 A.
Battery: 12 v 92 Ah.

Tractor Specifications:
Transmission: Mechanical 6 forward/1 reverse.
Clutch: Dry, single, disc.
Travelling speed km/h:
Forward: 1,2 - 2,7 - 3,9 - 5,5 - 9,2 - 15,3.
Reverse: 3,8.
Steering system: Mechanical, dry multi-plate clutches. Completely enclosed.

Wheels:
Front Traction Wheels: 10,50 x 18", 6 PLY.
Rear: 6,00 x 9", 10 PLY.
420 mm Steel Tracks.
Protection Frame: Tested in accordance with OECD-code.
Winch: Igland «Primo» single drum.
Pulling force 3000 kp.
Wirespeed 28 - 74 m/min.

Dimensions:

Length overall	3280 mm
Width overall	1530 mm
Height	2220 mm
With single drum winch	1700 kg



APPENDIX FH-7

MOR-BELL LOGGER

Loads tree length material

Pre-stacks for larger skidders

Sorting in yard

The Mor-Bell Logger can .....

- Load tree length stems in confined areas
- Pre-skid for larger skidders improving the large skidder efficiency
- Handle sawlogs around a wood yard — sorting — stacking — loading
- Load shortwood at the landing, especially in tight spots — improves load density by 10-15%
- Be used in small skyline operations — stacking and loading

Stacks shortwood

APPENDIX FH-7 (continued)

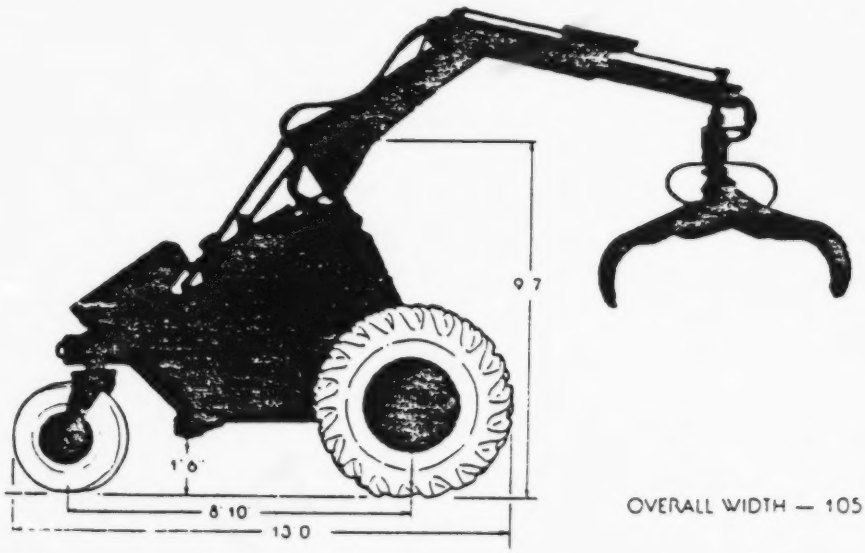
MOR-BELL LOGGER

OPTIONS AND PRICES

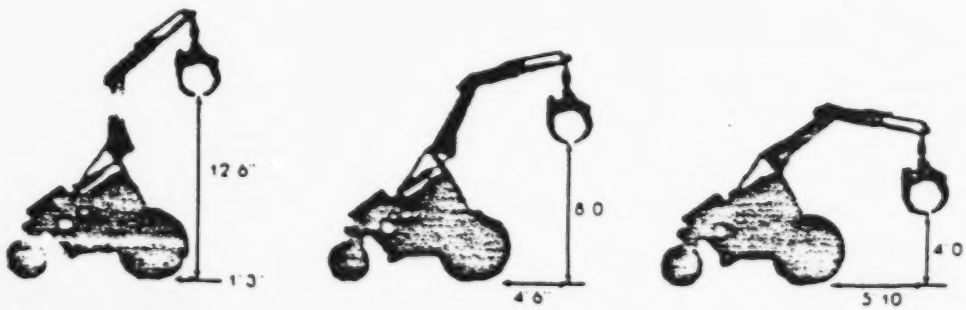
Standard Retail			**$52,500.00**
Wholesale			**$45,500.00**
Side Windows	$ 270.00	**Spare Parts Kit**	**$1,000.00**
Side Mirrors	$ 315.00	**Air Conditioner**	**$1,450.00**
Trelleborg 600 x 30 x-16 Ply Tires in lieu of standard tires	$3,000.00	**Chains (set)**	**$1,150.00**
5 % CASH DISCOUNT			

SPECIFICATIONS

ENGINE	Air Cooled, 50 H.P., 1 gal. per hour
DRIVE	Hydrostatic, 96% efficient, 0-8 MPH
FRAME	All welded, steel tubular frame, Roll over protection built in
GRAPPLE	Mor-Bell one ton opening, 60" maximum
WEIGHT	9,100 lbs.
GROUND PRESSURE	6-8 PSI
WIDTH.....Standard	8'10"
Narrow Tread	8'4"
GROUND CLEARANCE	18"



OVERALL WIDTH — 105"



APPENDIX FH-8

BDR MACHINERY LTD.

BRUKS 1300 M SLANTED DISC CHIPPER WITH FEEDWORKS

Patented chipper for high yield production of first class pulp chips from sawmill waste and roundwood.

Chipper is delivered as standard with horizontal infeed and top discharge, including feedwork capacity control panel plus feedwork motors and main drive motor (main motor starter and all cables to be provided and installed by customer). A manually operated brake is incorporated for safety during knife changes.

DATA

Disc Diameter	1230 mm	48 ins.
Disc Speed	- 740 RPM	-
Infeed width	375 mm	15 ins.
Infeed height	250 mm	10 ins.
Number of Knives	- 2	-
Knife dimension	400 x 135 x 14 mm	15 3/4" x 5¼" x 9/16"
Knife weight	4.5 kg	10 lbs.
Chip length (adjustable)	15 - 30 mm	5/8" - 1 3/16"
Chipper weight (w/o motor)	2100 kg	4600 lbs.
Feedwork motor	5 KW	7.5 HP
Main motor	35 - 55 KW	50 - 75 HP

Chipper Dimensions as per drawing 4-271

CAPACITIES	50 HP	60 HP	75 HP
Average M3 Chips/HR.	15	20	25
Surge M3 Chips/HR.	20	25	35

PRICE

Complete with Main Motor

FOB Mississauga, Ontario, Duty Paid. Taxes extra if applicable.

APPENDIX FH-9

CAPITAL COST ESTIMATE FOR WOOD BIOMASS
HARVESTING, PROCESSING & DELIVERY EQUIPMENT

1. WOOD HARVESTING BASED OPERATION		Estimated Cost
a) 2 Krabat Skidders - Haulers	New	$ 70,000
b) 3 Power Saws	New	1,500
c) 3 Logging Sleighs	Used	10,500
d) Fire Protection Equipment	New	600
e) Portable Logging Shed	Used	1,000
f) Miscellaneous Tools	Used	1,000
SUB-TOTAL		$ 84,600
2. WOOD FUEL COMPOUNDS		
a) 1 Light Delivery Sleigh (fuelwood)	Used	$ 2,000
b) 1 Mor-Bell Logger Grapple (Yard Fork-lift)	New	70,000
c) 2 Power Saws	New	1,000
d) 1 Log Splitter	New	1,500
SUB-TOTAL		74,500
3. PROCESSING COMPLEX		
a) Chipper - Electrical (50 kw)	New	$ 45,000
b) Sawmill (50 kw)	New	30,000
c) Planer (40 kw)	Used	20,000
d) Residue Blower (10 kw)	Used	2,500
e) Lumber Trimmer (3kw)	Used	1,500
f) Miscellaneous Tools & Equipment	New	3,000
SUB-TOTAL		$102,000

APPENDIX FH-9 (continued)

4. MAINTENANCE AND REPAIR

a) Filing and Grinding	New	$ 2,500
b) Power Saw Repair Equipment	New	500
c) Vehicle Overhaul & Maintenance Equipment	New	1,500
d) Spare Parts (all equipment)	New	10,000
SUB-TOTAL		$ 14,500
TOTAL LOGGING AND PROCESSING		$275,600

Straight Line Depreciation (5 years) = $47,920/yr

APPENDIX FH-10

DETAILS OF BIOMASS HARVESTING AND DELIVERY COSTS

ITEM	COST/CORD	COST/TONNE
	$	$
Cutting Plan	1.0	0.66
Roods & Strips	3.0	1.98
Felling	3.0	1.98
Limbing & Bucking	2.0	1.32
Loading	2.0	1.32
Skidding	8.0	5.28
Hauling	5.0	3.30
Compound Processing	2.0	1.32
Chipping	12.0	6.60
Overheads	3.0	1.98
Royalties to Band	1.0	0.66
TOTAL COST	42.00	26.40

APPENDIX FH-11

CAPITAL COST ESTIMATE COGENERATION ENERGY SYSTEM

a) Electrical Energy System

1.	Two (2) Steam Boiler Systems with stack & breeching 250 kw system Inlet 150 psi - outlet 15 psi	$ 400,000	
2.	Two (2) Steam Engines/Generator System 250 kw Inlet 160 psi - outlet 15 psi 350 hp - 11,250 lbs/hr	500,000	
3.	Building and Structures	250,000	
4.	Fuel Bunker & Delivery System 30' x 40' x 20' with push-rod system	150,000	
5.	Electrical Control & Distribution Fully automatic synchronization all components	100,000	
6.	Installation & Start-up	250,000	$1,650,000

b) Cogeneration System (Heating System)

1.	Heat Distribution System (Heat lines to and from all buildings)	$ 400,000	
2.	Feasibility & Conceptual Design	50,000	
3.	Detailed Engineering	40,000	
4.	Project Management	90,000	$ 580,000
TOTAL			$2,230,000

Write-off (15 years) = $148,600

APPENDIX FH-12

EMPLOYMENT POTENTIAL

Based on 2000 hrs/year

Work Activity	No. Employed	Period of Work	Hourly Rate $	Total Wages $
A. FOREST HARVESTING & PROCESSING				
1. Forest Harvesting				
3600 Cords/year Road Construction Reforestration				
- Workers	4	1/2	8.00	32,000
- Working Foreman	1	3/4	10.00	15,000
Sub-Total	5			47,000
2. Wood Products Processing				
Chipping biomass, fuelwood, lumber operation				
- Workers	4	2/3	7.00	37,300
- Working Foreman	1	2/3	10.00	13,300
Sub-Total	5			50,600
3. Maintenance & Repair				
Filing and grinding Vehicle maintenance				
- Worker (Trainee)	1	1/2	7.00	7,000
- Working Mechanic	1	3/4	10.00	15,000
Sub-Total	2			22,000
4. Management, Scaling, Secretarial				
- General Manager	1	1/2	12.00	12,000
- Scaler-Secretarial	1	1	6.00	12,000
	2			24,000
TOTAL HARVESTING & PROCESSING	14			143,600

APPENDIX FH-12 (continued)

B. OPERATION OF ENERGY SYSTEM

Boilerroom, Electrical Generation Heating System				
- Workers	4	1	9.00	72,000
- Manager	1	1/2	12.00	12,000
TOTAL OPERATION OF ENERGY SYSTEM	5			84,000
TOTAL EMPLOYMENT	19			227,600

Note:
Manager spends 1/2 year in boiler & half year overseeing harvesting & processing.

APPENDIX FH-13

ECONOMIC ANALYSIS DATA
- FORT HOPE -

SOURCE: ONTARIO MINISTRY OF ENERGY

Biomass Systems
Economic Assessment
20 Year Life

:Locations: :Resources
:Fort Hope :Heat: Electricity & Heat

Input -
Base 1984 Costs

Capital Cost:	2505600
O & M:	3048
Diesel O&M:	159000
Diesel Cap. Cost:	1060000

Output -
Present Values

Expenses	-341687.
Revenue	6474744.
Rate of Return (less grant	0.333221
Cost/kWh (diesel)	1.243316
Cost/kWh (biomass)	0.252778

Borrowing Structure Length of Term: 15 :

	Capital	Interest Rate	Yearly Payments	
Source 1	0	0.14	0	1
2	0	0.12	0	0
3	0	0	0	

Rates

Inflation	0.06
Discount	0.12

Real Value Table

Year	Expenses	Loan Pays	I/I	Fuel Cost	kWh	Bio. Cost	Revenue	PV Exps.	PV Rev.	Payback
1984	-155952	0	0.63	567782	300413.7	138749	429033	-155952	429033	
1985	-165309.	0	0.6775	622169	306110.2	151760	470409	ERR	ERR	
1986	-175227.	0	0.725	676556	311060.2	164771	511785	-287287.	827999.9	0
1987	-185741.	0	0.7725	730943	315401.5	177782	553161	-419494.	1221728.	1
1988	-196885.	0	0.82	785330	319239.8	190793	594537	-544619.	1599567.	1
1989	-208698.	0	0.894	868448.8	321806.4	200721.6	667727.2	-663040.	1978454.	1
1990	-221220.	0	0.968	951567.6	327674.7	210650.2	740917.4	-775119.	2353826.	1
1991	-234494.	0	1.042	1034686.	330993.7	220578.8	814107.6	-881191.	2722087.	1
1992	-248563.	0	1.116	1117805.	333872.5	230507.4	887297.8	-981582.	3084451.	1
1993	-263477.	0	1.19	1200924	336293.2	240436	960488	-1076594	3440813.	1
1994	-279286.	0	1.286	1320239	342208.1	255127.8	1065111.	-1166517	3769750.	1
1995	-296043.	0	1.382	1439554	347215.1	269819.6	1169734.	-1251622	4106021.	1
1996	-313806.	0	1.478	1558869	351571.7	284511.4	1274357.	-1332169	4433117.	1
1997	-332634.	0	1.574	1678184	355396.8	299203.2	1378980.	-1408406	4749144.	1
1998	-352592.	0	1.67	1797499	358782.2	313895	1483604	-1480547	5052718.	1
1999	-373748.	0	1.804	1977361.	365366.1	333632.6	1643729	-1548830	5353021.	1
2000	-396172.	0	1.938	2157224.	371039.5	353370.2	1803854	-1613454	5647269.	1
2001	-419943.	0	2.072	2337086.	375979.2	373107.8	1963979	-1674616	5933312.	1
2002	-445139.	0	2.206	2516949.	380318.7	392845.4	2124104	-1732502	6209529.	1
2003	-471848.	0	2.34	2696812	384161.2	412583	2284229	-1787287	6474744.	1

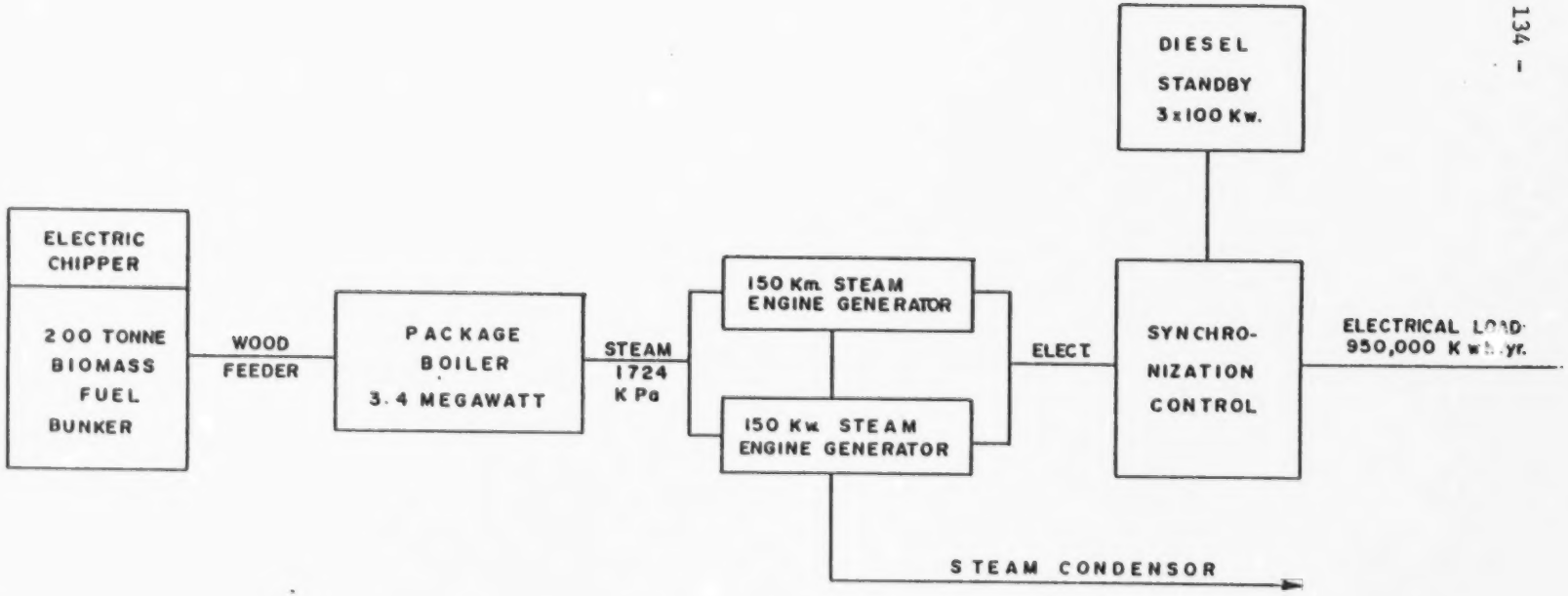
WEAGAMOW (ROUND LAKE) APPENDICES

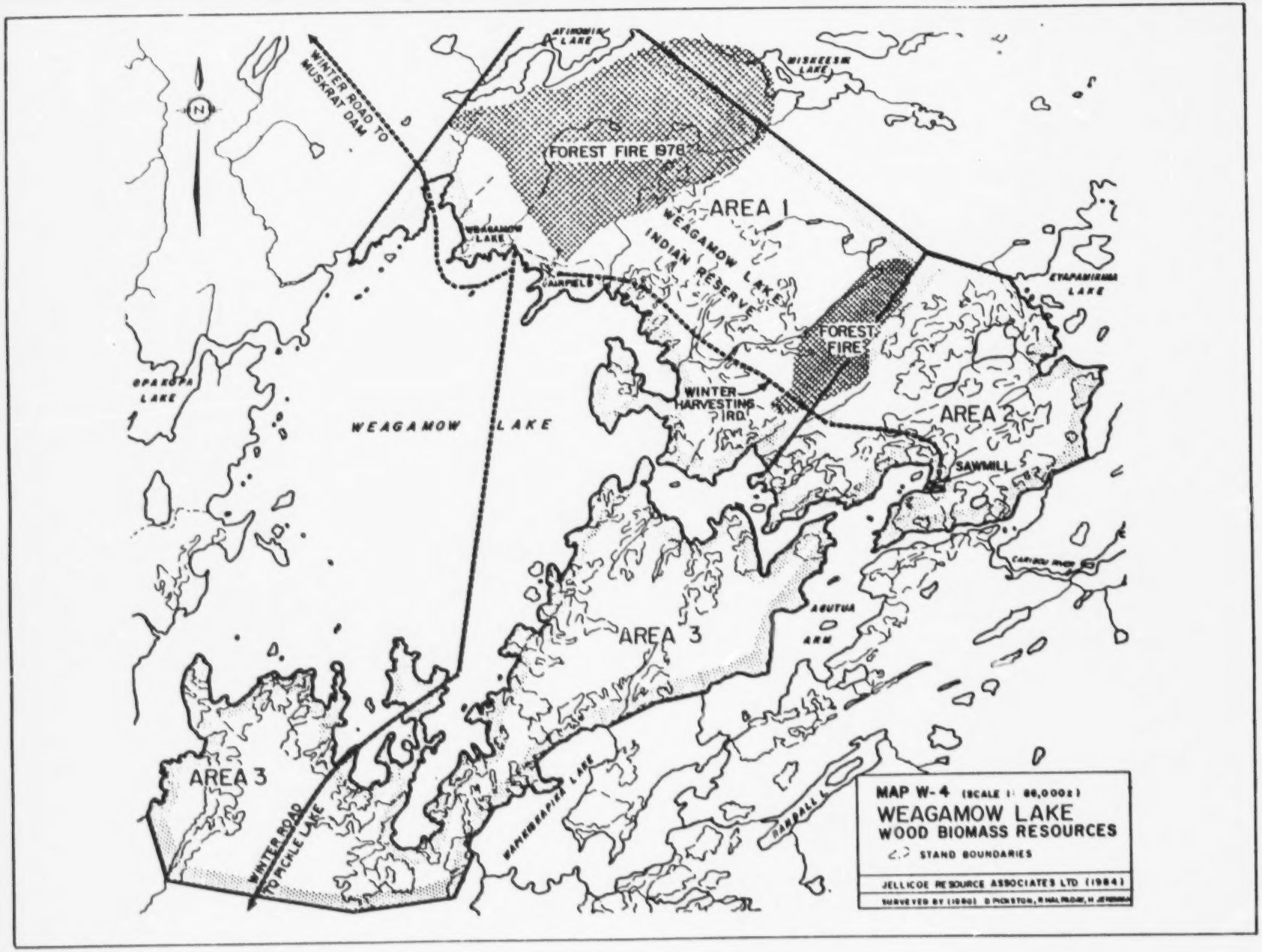
(W-1 to W-6)

APPENDIX W-1

WEAGAMOW

WOOD BIOMASS CO-GENERATION SYSTEM




WINTER ROAD TO MUSKRAT DAM
FOREST FIRE 1976
AREA 1
WEAGAMOW LAKE
INDIAN RESERVE
FOREST FIRE
WINTER HARVESTING RD.
AREA 2
SAWMILL
WEAGAMOW LAKE
AREA 3
AREA 3
WINTER ROAD TO PICKLE LAKE
MAP W-4 (SCALE 1: 80,000±)
WEAGAMOW LAKE
WOOD BIOMASS RESOURCES
STAND BOUNDARIES
JELLICOE RESOURCE ASSOCIATES LTD (1984)

APPENDIX W-3

CAPITAL COST ESTIMATE

WOOD BIOMASS HARVESTING, PROCESSING DELIVERY AND GENERATING SYSTEM COSTS

A. FOREST OPERATIONS

3 Power Saws	New	$ 1,500
4 Logging Sleighs (20 ton)	Used	10,500
2 Krabat Skidders & Haulers	New	70,000
7 km of winter road @ $3,000/km		21,000
Miscellaneous tools & equipment		1,000
		$104,000

B. WOOD COMPOUND

1 Mor-Bell Logger	New	$ 70,000
2 Power Saws	New	1,000
½ Ton Truck	Used	9,000
1 Bruks 1001 CT Trailer Chipping Unit (Electric)		45,000
		$125,000

C. ELECTRICAL GENERATION PLANT

2 - 150 kw Steam Engine/Generators	$ 260,000
1 - 350 HP (12,000 lb steam) (160 psi) package fire tube boiler	286,000
Construction Cost - Installation & Start-up	210,000
Transportation Cost	44,000
Synchronization to diesel units	120,000
Boilerhouse Costs	140,000
Fuel Bunker	80,000
	$1,140,000

D. MAINTENANCE & REPAIR

Filing & Grinding	New	2,500
Power Saw Repairs	New	500
Vehicle Overhaul	New	1,500
Spare Parts	New	10,000
		$ 14,500

TOTAL CAPITAL COSTS $1,383,500

Write-off Electrical Generation Plant (15 years) = $76,000

Write-off All Capital Costs (15 years) = $92,233

APPENDIX W-4

DETAILS OF WOOD BIOMASS HARVESTING AND DELIVERY COSTS

Items	Cost/Cord	Cost/Tonne
	$	$
Cutting Plan	1.00	0.66
Roads & Strips	3.00	1.98
Felling	3.00	1.98
Limbing & Bucking	2.00	1.32
Skidding	2.00	1.32
Loading	12.00	7.92
Hauling	10.00	6.60
Compound Processing	2.00	1.32
Chipping	12.00	7.92
Overheads	3.00	1.98
Royalties to Band or MNR	1.00	0.66
TOTAL COST	51.00	33.66

1 Cord = 1.5 tonnes

1 Tonne = .66 Cords

Note:

Operating Costs based on a production volume of 4,500 tonnes of biomass, 1,125 tonnes of fuelwood, and 750 tonnes of sawlogs (material in excess of ten inches).

APPENDIX W-5

EMPLOYMENT POTENTIAL

Based on 2000 hrs/year

Work Activity	No. Employed	Period of Work	Hourly Rate $	Total Wages $
A. PRODUCTION OF BIOMASS				
1. Forest Harvesting				
4250 Cords/year Road Construction Reforestration				
- Workers	4	1/2	10.00	40,000
- Foreman	1	3/4	12.00	18,000
SUB-TOTAL	5			58,000
2. Wood Products Processing				
Chipping biomass, fuelwood lumber				
- Workers	4	2/3	9.00	47,520
- Foreman	1	2/3	12.00	15,840
SUB-TOTAL	5			63,360
3. Maintenance & Repair				
Filing & grinding Vehicle maintenance				
- Worker	1	1/2	8.00	8,000
- Worker Mechanic	1	3/4	12.00	18,000
SUB-TOTAL	2			26,000
4. Management, Scaling, Secretarial				
- General Manager	1	1/2	15.00	15.000
- Scaler-Secretarial	1	1	7.00	14,000
SUB-TOTAL	2			29,000
TOTAL HARVESTING & PROCESSING	14			176,360

APPENDIX W-5 (continued)

Work Activity	No. Employed	Period of Work	Hourly Rate $	Total Wages $
B. ENERGY PLANT STAFFING				
Boilerhouse Workers	4	1	12.00	96,000
Boilerhouse Foreman	1	1	15.00	30,000
TOTAL ENERGY PLANT	5			126,000
TOTAL EMPLOYMENT POTENTIAL	19			
TOTAL MAN YEARS		14		
TOTAL WAGES				$302,360

APPENDIX W-6

ECONOMIC ANALYSIS DATA
-WEAGAMOW-

SOURCE: ONTARIO MINISTRY OF ENERGY

Biomass Systems
Economic Assessment
20 Year Life

Locations: Weagamow
Resources: Wood; Electricity

Input -
Base 1984 Costs

Capital Costs:	1383500
O & M:	110680
Diesel O&M:	103000
Diesel Cap. Cost:	979000

Output -
Present Values

Expenses	493516.6
Revenue	-723854.
Rate of Return (less grant	-1.84516
Cost/kWh (diesel)	0.744973
Cost/kWh (biomass)	1.157857

Borrowing Structure Length of Term: 15

	Capital	Interest Rate	Yearly Payments	
Source 1	0	0.14	0	1
2	0	0.12	0	0
3	0	0	0	

Rates

Inflation	0.06
Discount	0.12

Real Value Table

Year	Expenses	Loan Pays	B/I	Fuel Cost	kWh	Bio. Cost	Revenue	PV Exps.	PV Rev.	Payback
1984	7680	0	0.39	87138	74476.92	167425	-80287	7680	-80287	
1985	8140.8	0	0.415	95406	76631.32	181440.5	-86034.5	ERR	ERR	
1986	8629.248	0	0.44	103674	78540.90	195456	-91782	14147.75	-149984.	0
1987	9147.002	0	0.465	111942	80245.16	209471.5	-97529.5	20658.41	-219404.	0
1988	9695.823	0	0.49	120210	81775.51	223487	-103277	26820.28	-285038.	0
1989	10277.57	0	0.536	135169	84060.32	238795.6	-103626.	32652.05	-343839.	0
1990	10894.22	0	0.582	150128	85983.96	254104.2	-103976.	38171.40	-396516.	0
1991	11547.88	0	0.628	165087	87625.79	269412.8	-104325.	43395.08	-443708.	0
1992	12240.75	0	0.674	180046	89043.52	284721.4	-104675.	48338.91	-485984.	0
1993	12975.19	0	0.72	195005	90280.09	300030	-105025	53017.90	-523858.	0
1994	13753.71	0	0.778	215802	92460.15	320133.8	-104331.	57446.22	-557450.	0
1995	14578.93	0	0.836	236599	94337.71	340237.6	-103638.	61637.32	-587243.	0
1996	15453.66	0	0.894	257396	95971.66	360341.4	-102945.	65603.89	-613667.	0
1997	16380.88	0	0.952	278193	97406.51	380445.2	-102252.	69357.97	-637100.	0
1998	17363.74	0	1.01	298990	98676.56	400549	-101559	72910.93	-657881.	0
1999	18405.56	0	1.09	329601.2	100795.4	426793	-97191.8	76273.56	-675638.	0
2000	19509.90	0	1.17	360212.4	102624.6	453037	-92826.6	79456.05	-690780.	0
2001	20680.49	0	1.25	390823.6	104219.6	479281	-88457.4	82468.05	-703663.	0
2002	21921.32	0	1.33	421434.8	105622.7	505525	-84090.2	85318.69	-714598.	0
2003	23236.60	0	1.41	452046	106866.6	531769	-79723	88016.61	-723854.	0

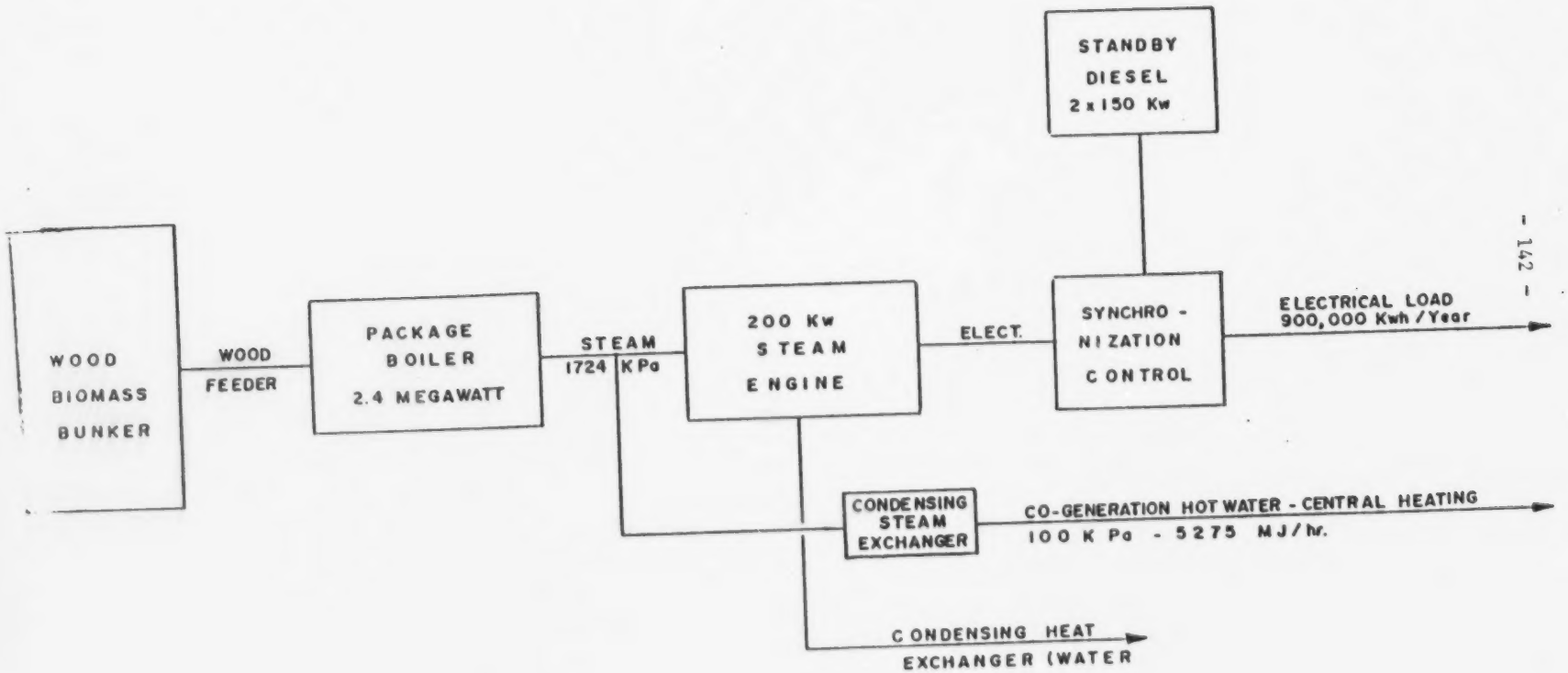
GULL BAY APPENDICES

(G-1 to G-5)

APPENDIX G-I

GULL BAY

WOOD BIOMASS STEAM BIOLER / STEAM ENGINE COMBINATION



APPENDIX G-2

CAPITAL COST ESTIMATE WOOD BIOMASS

HARVESTING, PROCESSING DELIVERY AND GENERATING EQUIPMENT

A. HARVESTING AND TRANSPORTATION OF BIOMASS

1.	Mor-Bell Logger	New	$ 60,000
2.	Krabat Logger Unit	New	35,000
3.	Trailer Mounted Chipper 100 horse power	New	50,000
4.	2 Power Saws	New	1,000
5.	Dump Truck (10 tons)	Used	10,000
SUB-TOTAL			$156,000

B. BIOMASS ENERGY SYSTEM

1.	Steam Boiler 250 HP - 160 psi Package Fire Tube	$210,000
2.	1-200 kw Steam Engine/Gen. Unit	190,000
3.	Bunker Construction	150,000
4.	Boilerhouse	95,000
5.	Transportation	15,000
6.	Installation & Start-up	160,000
SUB-TOTAL		$820,000

TOTAL COST OF ENERGY SYSTEM (A & B) $976,000

Write-off (15 years) = $65,066

See the Appendices for more information on the biomass system equipment

APPENDIX G-3

DETAILS OF WOOD BIOMASS

HARVESTING AND DELIVERY COSTS

	Cost/Green Tonne
1. Landing & Roads	$ 2.00
2. Felling	3.00
3. Residue Gathering & Skidding	10.50
4. Chipping Cost	12.00
5. Hauling & Unloading	6.00
6. Royalties or Stumpage	1.00
COST PER GREEN TONNE	$34.50

APPENDIX G-4

EMPLOYMENT POTENTIAL

Based on 2000 hrs/year

WORK ACTIVITY	NO. EMPLOYED	PERIOD OF WORK	HOURLY RATE ($)	TOTAL WAGES ($)
A. PRODUCTION OF BIOMASS				
1. Forest Harvesting				
tonnes/year				
- workers	3	3/4	10.00	45,000
- foreman	1	1	12.00	24,000
2. Biomass Bunker				
- workers	2	1	10.00	40,000
TOTAL HARVESTING & PROCESSING	6			109,000
B. ENERGY PLANT STAFFING				
- boilerhouse workers	4	1	12.00	96,000
- boilerhouse foreman	1	1	14.00	28,000
TOTAL ENERGY PLANT	5			124,000
TOTAL A & B	11			233,000

APPENDIX G-5

ECONOMIC ANALYSIS DATA
- GULL BAY -

SOURCE: ONTARIO MINISTRY OF ENERGY

Biomass Systems
Economic Assessment
20 Year Life

Location: Gull Bay
Resources: Wood: Electricity

Input - Base 1984 Costs

Capital Costs:	976000
O & M:	68320
Diesel O&M:	70200
Diesel Cap. Costs:	595000

Output - Present Values

Expenses	369454.2
Revenue	-860357.
Rate of Return (less grant	-1.84065
Cost/kWh (diesel)	0.701787
Cost/kWh (biomass)	1.194887

Borrowing Structure Length of Term: 15

	Capital	Interest Rate	Yearly Payments	
Source 1	0	0.14	0	1
2	0	0.12	0	0
3	0	0	0	

Rates

Inflation	0.06
Discount	0.12

Real Value Table

Year	Expenses	Loan Pays	I/I	Fuel Cost	kWh	Bio. Cost	Revenue	PV Exps.	PV Rev.	Payback
1984	-1980	0	0.35	86580	82457.14	184575	-97995	-1880	-97995	
1985	-1992.8	0	0.3775	95054.75	83933.55	198446.7	-103392	ERR	ERR	
1986	-2012.36	0	0.405	103529.5	85209.46	212318.5	-108789	-3463.25	-179040.	0
1987	-2239.11	0	0.4325	112004.2	86323.12	226190.2	-114186	-5057.00	-260315.	0
1988	-2373.45	0	0.46	120479	87303.62	240062	-119583	-6565.28	-336312.	0
1989	-2515.86	0	0.502	132849.4	88213.41	253765.8	-120916.	-7992.95	-404923.	0
1990	-2666.81	0	0.544	145219.8	88982.72	267469.6	-122249.	-9344.04	-466859.	0
1991	-2826.82	0	0.586	157590.2	89641.75	281173.4	-123583.	-10622.7	-522762.	0
1992	-2996.43	0	0.628	169960.6	90212.63	294877.2	-124916.	-11832.9	-573213.	0
1993	-3176.22	0	0.67	182331	90711.94	308581	-126250	-12978.3	-618740.	0
1994	-3366.79	0	0.724	199071.4	91153.49	326263.6	-127192.	-14062.3	-659693.	0
1995	-3568.80	0	0.778	215811.8	92464.35	343946.2	-128134.	-15088.3	-696529.	0
1996	-3782.92	0	0.832	232552.2	93169.95	361628.8	-129076.	-16059.2	-729659.	0
1997	-4009.90	0	0.886	249292.6	93789.54	379311.4	-130018.	-16978.2	-759456.	0
1998	-4250.49	0	0.94	266033	94337.94	396994	-130961	-17847.9	-786253.	0
1999	-4505.52	0	1.016	291696.4	95700.91	411666.2	-119969.	-18671.1	-808171.	0
2000	-4775.86	0	1.092	317359.8	96874.17	426338.4	-108978.	-19450.1	-825948.	0
2001	-5062.41	0	1.168	343023.2	97896.74	441010.6	-97987.4	-20187.4	-840220.	0
2002	-5366.15	0	1.244	368686.6	98790.62	455682.8	-86996.2	-20885.3	-851533.	0
2003	-5688.12	0	1.32	394350	99583.33	470355	-76005	-21545.7	-860357.	0